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EDITED BY J. McKEEN CATTELL

CONTENTS

THE MYRIAD-MINDED LEONARDO DA VINCI, FORERUNNER OF MODERN SCIENCE. Don Gelasio Caetani 449

THE MOTIONS OF THE STARS AND THE EXISTENCE OF A VELOCITY RESTRICTION IN A UNIVERSAL WORLD-FRAME. Dr. Gustaf Strömberg 465

PARASITISM AMONG THE INSECTS. Dr. Francis Metcalf Root 479

FIVE FUNDAMENTAL CONCEPTS OF PURE MATHEMATICS. Professor G. A. Miller 496

IS THERE A NATURAL LAW OF INEQUALITY? Professor Ira Woods Howerth 502

PHILOSOPHY IN MEDICINE. Professor Horst Oertel 512

THE PHYSICAL BASIS OF DISEASE. The Research Worker 520

OCCUPATIONAL DIFFERENTIAL FECUNDITY. Hornell Hart 527

HIGHER MENTAL AND PHYSICAL STANDARDS FOR IMMIGRANTS. Professor R. DeC. Ward 533

THE MANAGEMENT OF FOREST PROPERTIES IN THE CALIFORNIA REGION. S. B. Show 548

THE PROGRESS OF SCIENCE:
The Speed of Light; The Melting Pot; The Senility of Civilization 553

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THE SCIENTIFIC MONTHLY

NOVEMBER, 1924

THE MYRIAD-MINDED LEONARDO DA VINCI, FORERUNNER OF MODERN SCIENCE

By DON GELASIO CAETANI

ITALIAN AMBASSADOR TO THE UNITED STATES

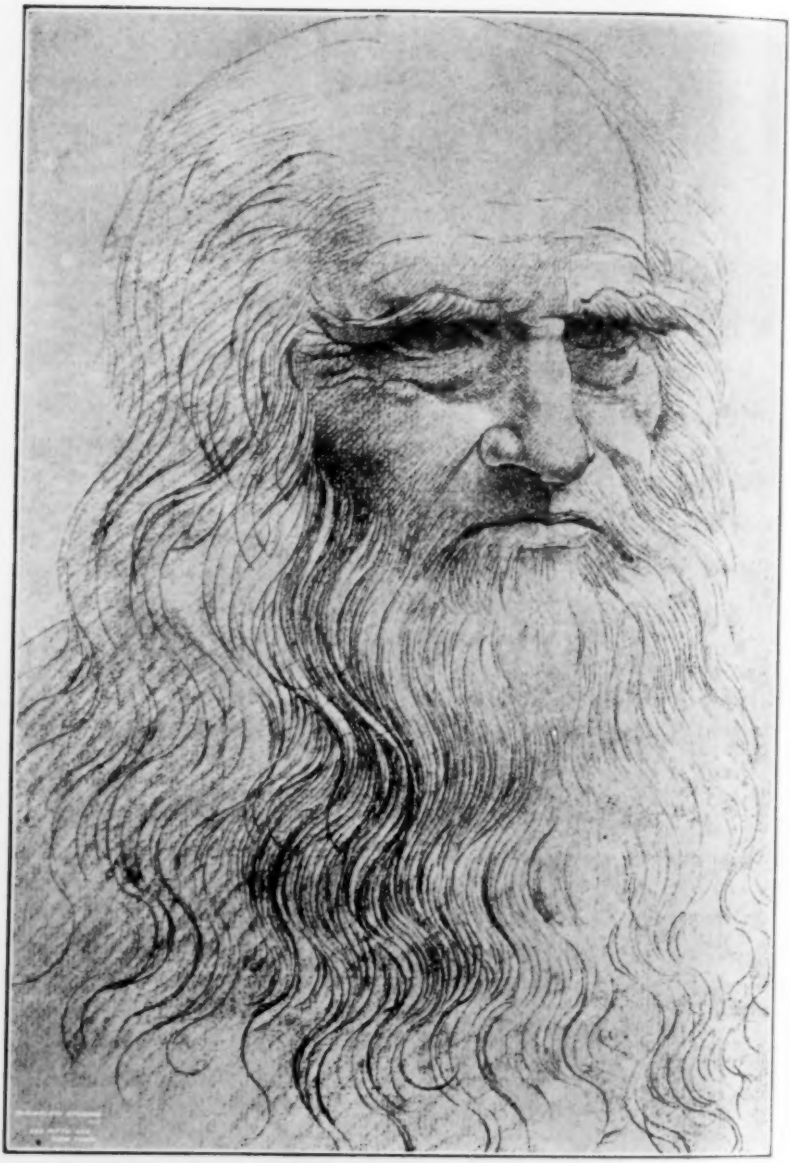
IT is generally believed that the Italians are eminently artistic, which is quite true; it is even believed that they are principally and solely artistic, which is perfectly wrong.

The fundamental and characteristic trait of the Italian race is its aptitude towards scientific speculation and towards technical achievement; and the marvelous artistic production for which my country is best known to the peoples of the world is essentially the fruit of a technical tendency to which the beauty-seeking temperament of the Italian people has given a superior artistic expression.

Dante was principally a philosopher and theologist; his purpose in writing the Divine Comedy was to expose his political and theological conception and, at a time when only Latin was used for literary purposes, he availed himself of a so far unused though marvelous vehicle of expression, which was the Italian language; in doing so, his we can well say superhuman artistic temperament gave to his thoughts an expression that has classed him as the greatest poet of the world.

Michelangelo, known principally as a painter and sculptor, was essentially an engineer and architect who ornamented the buildings and monuments that he was requested to construct. So were Bramante, Leonardo da Vinci, Benvenuto Cellini, Luca della Robbia and many and many others.

What is essentially characteristic of the Italian Renaissance, and even somewhat of the following periods, is not the large number of first-class artists who have revealed themselves, but the remarkably exquisite artistic form that was given to every object that came out of the hands of all Italian craftsmen. No carpenter seems to have been able to cut wood with his chisel, no blacksmith to forge iron with his hammer, no mason to lay stone on stone with-



LEONARDO DA VINCI'S PORTRAIT OF HIMSELF

out producing an object of art. The most marvelous manifestation of the Renaissance is not so much the production of its leading artists as that of its unknown artisans.

In the midst of this multitude of known and unknown men of genius one figure towers above all "from the belt upward," as Dante says of Farinata, and that is Leonardo da Vinci. He is characteristically the engineer-artist of the Italian people and doubtless the most universal genius the human race has produced.

Certainly a majority of the people of the United States have heard or read of Leonardo da Vinci; probably nine out of ten know him as a great painter, but only one of these ten knows that his achievements as a technical genius are far greater than those as a painter.

Leonardo was born in 1452, in a village called Vinci, from which he took his name. He was the illegitimate child of an obscure public notary and of a woman of the peasant class.

Brought up in poverty, Leonardo taught himself by watching others and by taking nature as his teacher. In talking about himself this forerunner of modern scientists and technical men says:

> I am fully aware that the fact of my not being a man of letters may cause certain arrogant persons to think that they may with reason censor me, alleging that I am a man ignorant of book learning. Foolish talk! . . . They will say that because of my lack of book learning I can not properly express what I desire to treat of. Do they not know that my subjects require for their exposition experience rather than the words of others? And since experience has been the mistress of whoever has written well, I take her as my mistress, and to her in all points make my appeal.

A few years before America was discovered his personality had brought him into prominence at the ducal court of Ludovico il Moro in Milan.

I have not the space to give an account of his life and his achievements; therefore, I will limit myself solely to the enumeration of some of the astounding observations and discoveries that Leonardo da Vinci made.

These he formulated in laconic sentences scribbled with the left hand in the 5,300 sheets of his note-books that have luckily survived. He was left-handed and it came natural to him to write backwards, from right to left, in what is called "mirror writing" because it can be more easily read by using a mirror. He wrote carelessly for himself, making use of any space left around his sketches and drawings; philosophic consideration and scientific observations are strangely mixed up with unimportant memorandums and laundry bills. He was writing for himself, not for the public.

We now scrutinize with a lens his notes and sketches, gleaning in them with unceasing wonder the fundamental principles on which modern science and industry are based. It looks almost as if nothing had escaped his eagle eye. He understood the fundamental principles of astronomy, of paleontology and geology; he gave a description of human anatomy that can hardly be surpassed to-day; he invented the machine gun, the shrapnel, the Broadway elevated, the submarine; designed and tried a flying machine; made plans for a spring-driven automobile . . . and what not![1]

Maybe you remain incredulous: let me tell you. I am not going to attempt a coordinated and progressive exposition of his achievements, but will give a series of statements that convey more abruptly and more impressively the greatness of his genius. Whenever possible, I will use his words.

In 1480, Leonardo wrote to Ludovico il Moro, Duke of Milan, offering his services and stating without much modesty all the things he could do as a military engineer and as an artist; it is a series of blunt statements made by a man who knew he could do what he said he would do.

The duke listened to his words. For fifteen years Leonardo served faithfully his lord, making good use of the opportunities that were offered him, or, as he expressed it himself in his notes:

> When fortune comes seize her with a firm hand and in front, I counsel you, for behind she is bald.

Leonardo devoted his leisure hours to painting and did not hurry. They say that he worked for years on the portrait of "Mona Lisa," never satisfied, seeking something that perhaps he was not himself able to define; this is revealed to us by the mysterious smile and searching look of that woman whose face, after the lapse of four centuries, still reflects to us, like a living mirror, the thoughts of the man who gazed at her with the brush in his hand.

Little is left of his artistic work. Not over four or five pictures can with certainty be attributed to the master's hand; of his sculptures not even one has survived. Fate and the stupidity of man have acted harshly towards his artistic creations; fortunate circumstance instead has miraculously assured his immortal fame by saving his manuscripts, while to us they are the principal proof of his many-sided genius.

Did Leonardo realize this when he wrote the conundrum:

> Feathers shall raise men even as they do birds towards heaven:—That is by letters written with their quills.

[1] See McCurdy, "Leonardo da Vinci's Note Books" and John W. Lieb's paper presented to the Franklin Institute in 1921 from which I have largely drawn for my quotations.

MONA LISA

For briefness sake I must omit Leonardo's treaty on painting, his research work in chemistry and physics and his philosophic considerations; but I can not refrain from quoting his wise counsel to men in public life:

> Words which fail to satisfy the ear of the listener always either fatigue or weary him; and you may often see a sign of this when such listeners are frequently yawning. Consequently, when addressing men whose good opinion you desire, either cut short your speech when you see these signs of impatience, or else change the subject.

In astronomy Leonardo broke his way through and above the crystallized conceptions of his contemporaries and had a clear vision of the truth. Over 150 years before Galileo Galilei was sentenced by the ecclesiastical tribunal for having proclaimed the motion of the earth, Leonardo wrote: "The sun does not move; the earth is a star." To a certain extent he anticipated Newton by pointing out the universality of gravitation not merely on the earth but in the moon also. (Lieb, *op. cit.*, p. 23.) The spots on the moon puzzled him, and he says:

> The moon is not luminous in itself . . . When all that we can see of the moon is illuminated it gives us its maximum of light, and then from the reflection of the rays of the sun which strike upon it and rebound toward us its ocean throws off less moisture to us.

His eyes strained themselves in trying to detect the nature of the markings on the moon; if he did not precede Galileo in the construction of the telescope, he anticipated him in the desire of magnifying distant images, as appears from a brief sentence jotted in one of his note-books: "Construct glasses to see the moon magnified."

In geology he came very close to the truth by stating that the deluge was not universal but must have been a local inundation; he clearly formulated the transformation to which the continents have been subjected by the phenomena of mountain erosion and sedimentary deposits and from a close analysis of the fossil marine shells came to the conclusion that important geologic upheavals must have taken place in bygone ages.

Leonardo advocated the close study of human anatomy for the sake of art and science and did not hesitate to defy the canons of the church that threw the ban of excommunication on those who practiced dissection of the human body.

He was not deterred, as he says, "by the fear of passing the night hours in the company of these corpses, quartered and flayed and horrible to behold."

> I have dissected more than ten human bodies destroying all the various members, and removing even the very smallest particles of the flesh which surround these veins without causing any effusion of blood other than the

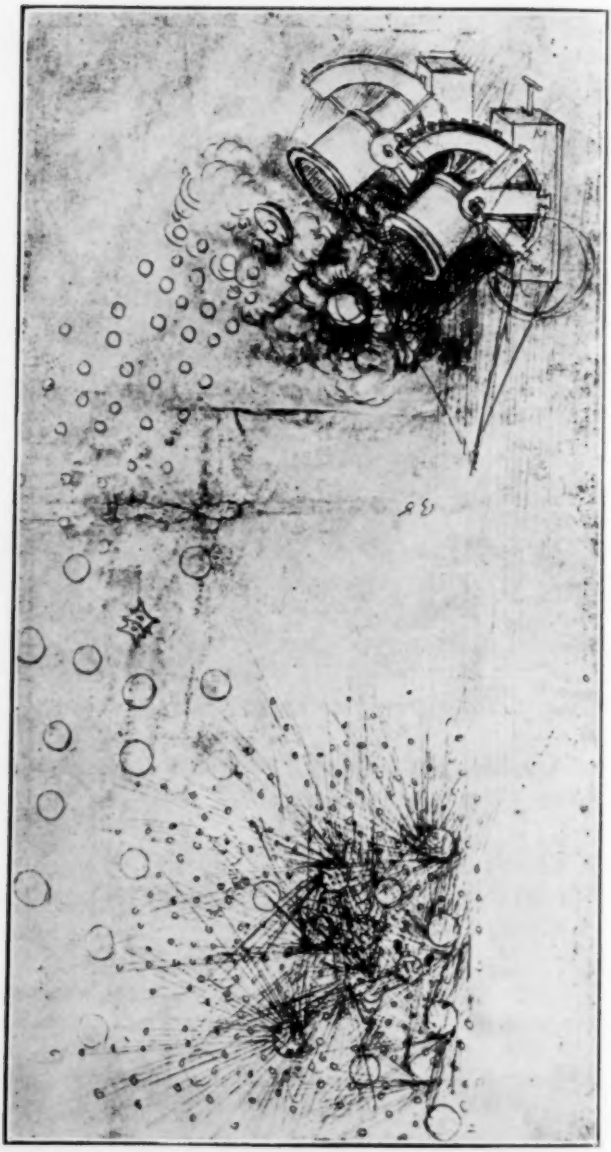
ANATOMICAL DRAWINGS

imperceptible bleeding of the capillary veins . . . and this I repeated twice in order to discover the differences. . . .

And if you say that as the blood becomes thicker it ceases to flow through the veins, this is not true because it continually dies and is renewed.

He gives an accurate description of arteriosclerosis, that is, the hardening of the arteries.

The death of old men, without fever, is caused by the veins, which, going from the spleen of the liver, have their skin become so thick that they close and no longer give passage to the blood which nourishes them. The continued flow of blood in his veins causes the veins to become thick and callous so that at last they close and prevent the blood from flowing. An old man, a few hours before his death, told me that he had lived a hundred years and did not feel any bodily ailment other than weakness, and thus while sitting upon a bed in the hospital of Santa Maria Nuova at Florence, without any movement or sign of anything amiss he passed away from his life. And I made an autopsy in order to ascertain the cause of so peaceful a death, and found that it proceeded from weakness through failure of blood and of the artery that feeds the heart and the other lower members which I found to be very parched and shrunk and



MORTAR FOR THROWING BOMBS AND SHRAPNEL

withered; and the result of this autopsy I wrote down very carefully and with great ease, for the body was devoid of either fat or moisture, and these form the chief hindrance to the knowledge of its parts. The other autopsy was on a child of two years, and here I found everything the contrary to what it was in the case of the old man.

Military engineering gave Leonardo a broad field in which to apply his ingenuity and I must limit myself to citing only a few of his inventions.

There is his mortar for throwing bombs and shrapnels that explode in the air; his cylindrical bullets with vanes cut out of the shaft are identical with the darts that were invented at the beginning of the world war to be dropped from aeroplanes to the benefit of the pedestrians. He discussed the advantage of rifling cannons and made a drawing of a machine-gun. There would appear (Lieb, *op. cit.*, p. 41) to be a reference to cartridges in these words:

The mounted carabineers must be provided with slender and simple tubes full of powder, with the ball inside so that they can be readily inserted and in this way an immense number of the enemy will be vanquished, and these carabineers must form in squadrons the same as arbalesters so that one part of them can fire while the other loads, but first be sure to accustom the horses to these noises or better stop up their ears.

One of the most striking statements Leonardo makes is when he refuses to describe the submarine, foreseeing the cruelties and havoc of human lives that would follow if man got into his hands such a treacherous and powerful instrument of destruction:

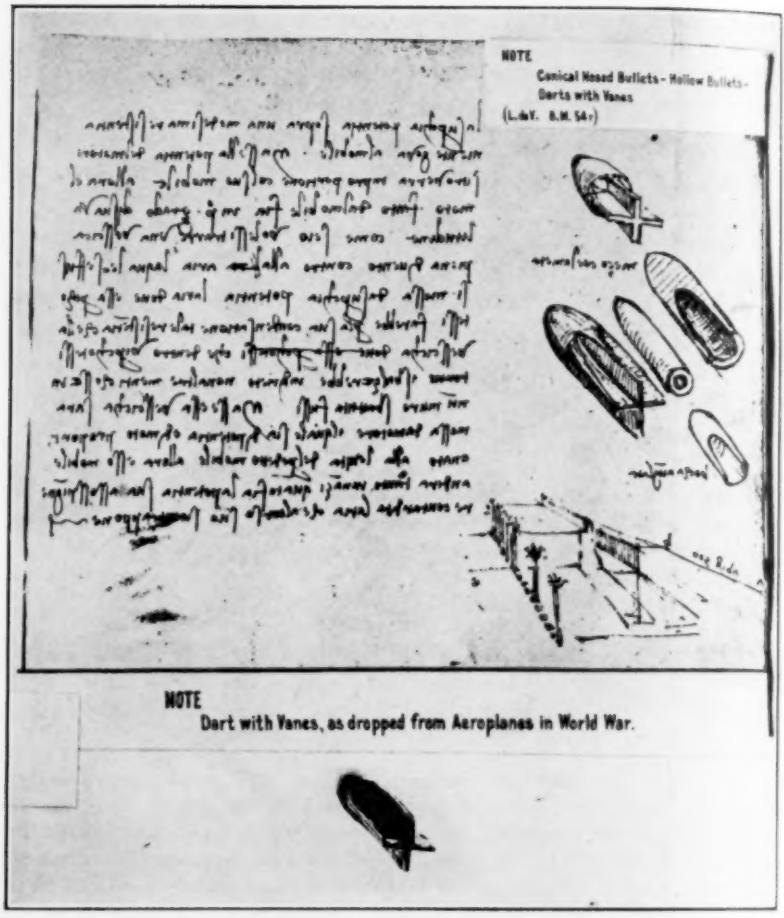
Why is it that I do not describe my method of remaining under water? How long can I stay without eating? These I do not publish or reveal on account of the evil nature of men, who would practice assassination on the bottom of the seas, by breaking the hulls of boats and wrecking them with all on board; while I tell about other means of submergence there is no danger from these because on the surface of the water there appears the mouth of the aspiration tube floating on skins or cork.

For each evil Leonardo sought a remedy; to detect a distant vessel he says:

If you cause your ship to stop, and place the head of a long tube in the water, and place the other extremity to your ear you will hear ships at a great distance from you.

In case of shipwreck he suggests a life preserver as the only safe and efficient device and for this:

It is necessary to have a coat made of leather with a double hem over the breast the width of a finger and double also from the girdle to the knee and let the leather of which it is made be quite air-tight. And when you are obliged to jump into the sea, blow out the lapels of the coat through the hems at the breast and then jump into the sea. And always keep in your mouth the end of the tube through which the air passes into the garment, and if once


NOTE
Conical Nosed Bullets - Hollow Bullets -
Darts with Vanes
NOTE
Dart with Vanes, as dropped from Aeroplanes in World War.

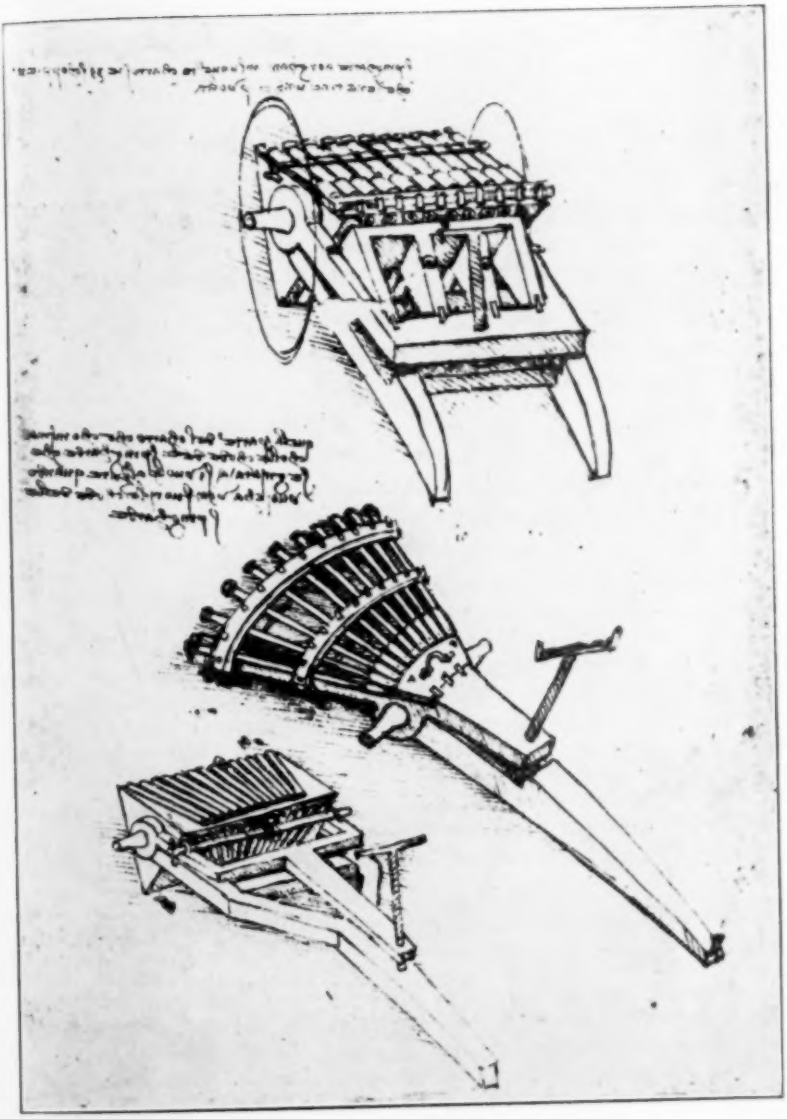
CYLINDRICAL BULLETS WITH VANES CUT OUT OF THE SHAFT

or twice it should become necessary for you to take breath when the spray prevents you, draw it through the mouth of the tube from the air within the coat.

Even the possibility of using poisonous gases did not escape his mind:

Throw among the enemy ships, with small catapults, chalk, pulverized arsenic and verdigris. All who inhale this powder will be asphyxiated by breathing it, but be careful that the wind be such as not to blow back the fumes, or else cover your nose and mouth with a moist cloth so that the powder fumes can not penetrate.

Who would dream that about the time Columbus was first landing in America, there should have lived a man who put into writ-



DRAWING OF MACHINE GUNS

ing the proper remedy to solve the traffic problem of the city of New York. Leonardo's plan in part has already been carried out by the construction of the elevated and the subway but the humble and harshly persecuted motor-car-dodging pedestrian of New York will some day erect a monument to the Italian engineer only when the city council will have fully carried out Leonardo's plan, which provides that:

> The model cities will be served by two kinds of streets; highways elevated or on a slope, elegantly ornamented and perfectly clean; and lower or subterranean roadways, washed from time to time by limpid water from the watercourse, and from which the refuse will be removed with rakes.
>
> In such a way that whoever wishes to travel by the elevated highway may do so at will; and also whoever wanted to go by the lower route will be free to do so. Vehicles (read motorcars) will never make use of the upper highway, reserved for gentlemen; while in the lower street the wagons and beasts of burden for work and for the supplies of the people will circulate.

Strange and marvelous are these discoveries and inventions of Italy's great genius, but none of his investigations brings him closer to our times and reveals better his absolutely modern methods of gradually and scientifically approaching and analyzing a technical problem than his attempt to solve the problem of human flight.

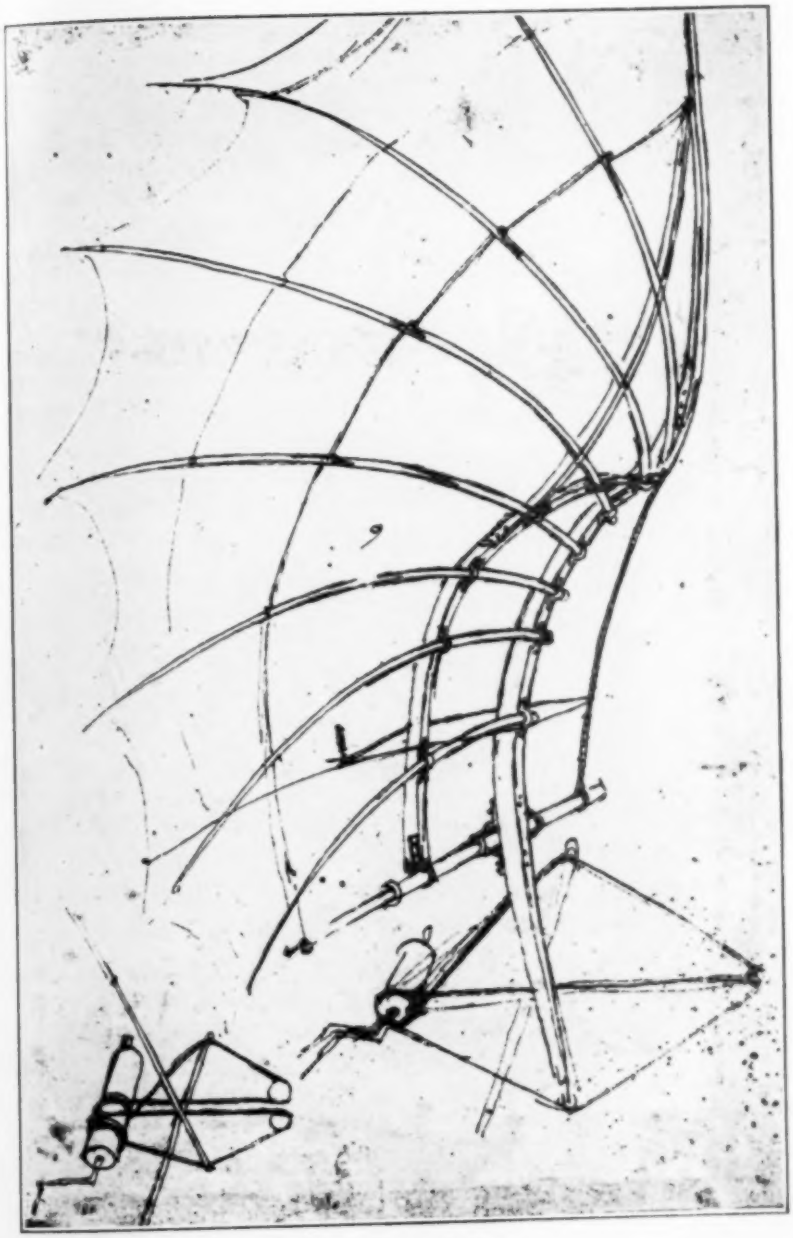
As John W. Lieb says in his paper (*op. cit.*, p. 56):

> Leonardo's pioneer work in the field of aviation would alone entitle him to the highest place as a scientist and engineer, for the science, skill and ingenuity he displayed in his endeavor to solve one of the great problems of the ages, artificial flight, even though he may have achieved no practical results. The record of his work in this field lay dormant and unappreciated for nearly four hundred years, during which the only substantial progress made towards its solution is synthetized in the expression "Lighter than air machines." The full importance of these marvelous records is not recognized by students of aviation problems even to-day, although emphasized by students of Leonardo like McCurdy, Beltrami and others, and they will only reach fruition when attention becomes again concentrated on human flight unaided by external power.

Leonardo approached the problem in the right way, that is, by first studying in minute detail the flight of the birds.

> I have divided the Treatise on Birds into four books; of which the first treats of their flight by beating their wings; the second of flight without beating the wings and with the help of the wind (soaring); the third of flight in general, such as that of birds, bats, fishes, animals and insects; the last, of the mechanism of this movement.

Especially important from our modern point of view is his analysis of the soaring flight, where he clearly defines the principles on which our airplane practice is based. This is how he describes the governing of a soaring flight by the use of the tail rudder and by the warping of the wings, which is Wilbur Wright's principal invention.



SKETCH OF FLYING MACHINE

Therefore we may be certain in the case of those birds which can support themselves above the course of the winds without beating their wings, that a slight movement of wing or tail, which will serve them to enter either below or above the wind, will suffice to present the fall of the said birds.

The helms (rudderlike articulations of the wings) which are on the shoulders of the wings are necessary when the bird in its flight without beating its wings wishes to maintain itself in part of a tract of air, upon which it is either slipping down or rising, and when it wishes to bend either upwards or downwards or to right or left. It then uses these helms in this manner: if the bird wishes to rise it spreads the helms in the opposite direction to the way the wind strikes it; and if to descend it spreads the top part of the helm slanting to the course of the wind. If it turns to the right it spreads the right helm to the wind, and if it turns to the left it spreads the left helm to the wind.

When the bird rises up by the assistance of the wind without beating its wings, it spreads out and raises its wings so that they form an arch with the concave side towards the sky, and it receives the wind under its wings continually, in its movement to and fro . . .

The fundamental element for the flight with motorless gliders that have stirred so much interest in these last two years in Germany and France, that is, a raising air current, is fully explained by Leonardo:

The bird rises to a height in a straight line without beating its wings when the reflex current of the wind strikes it from underneath.

The kite and other birds which move their wings only a little way go in search of the current of the wind; and when the wind is blowing at a height they may be seen at a great elevation, but if it is blowing low down, they remain low.

When there is no wind stirring in the air then the kite beats its wings more rapidly in its flight, in such a way that it rises to a height and acquires an impetus; with which impetus, dropping then very gradually, it can travel for a great distance without moving its wings.

After having understood the principles of flight, Leonardo attempted to fly himself. First he tried it out with a little pasteboard model:

Construct to-morrow figures (models) of pasteboard of various forms and make them to descend in the air by dropping them from a bridge; and then draw the curves and the motions which the fall of each makes in various parts of its descent.

He experimented also with the helicopter and the parachute:

If a man has a canopy of water-proof canvas, that is 24 feet on each side and 24 feet high, he can throw himself from any great height without damage to himself.

From these experiments he found out the wise maxim dear to all our modern aviators that:

In testing flying machines do not fly too near the ground, for if you fall you will not have time to right your machine before hitting the ground.

THE HELICOPTER

We have no positive proof that Leonardo actually attempted to fly on an apparatus constructed by himself, though he seems to hint at the intention of doing so when he writes:

> The first flight of the big bird will take place from the lofty Swan Hill (near Florence) and the universe will be filled with its praises and the nest whence it sprang will be filled with eternal glory.

Needless to say that his experiment must have been a failure, judging from what Gerolamo Cardano wrote shortly after his death: "It (the artificial flight) has turned out badly for the two who have recently made a trial of it. Leonardo da Vinci . . . has

attempted to fly but he was not successful." (Lieb, *op. cit.*, p. 60.)

Perhaps this unsuccess prompted him to write:

> Experience is never at fault; it is only our judgment that is in error in promising itself from experience things which are not within her power.

This is, as briefly as can be stated, the story of Leonardo da Vinci's achievements. I do not intend to claim that a unique genius like Leonardo can be taken as an illustrative example of the Italian race; but nobody can affirm that his genius was a mere fluke because the Italian generations that preceded and followed him gave birth to hundreds of men who ranked a close second to him. But Leonardo's achievements emphasize the statement made at the beginning of this article, that is, that the Italian mind has essentially a scientific and technical trend to which the artistic temperament of the people has given an expression of unparalleled beauty.

The scientific and technical tendency of the Italian people remained unimpaired even when the wonderful flowering of the Renaissance came to an end. It would astonish more than one American to hear the leading part that sunny Italy has had in the development of modern astronomy, anatomy, physics, chemistry, electricity and mathematics.

America is the land of technical achievements; to these Italy has silently contributed with the power of her intellect, and she is more proud of this than of the achievements of Christopher Columbus and Amerigo Vespucci.

THE MOTIONS OF THE STARS AND THE EXISTENCE OF A VELOCITY-RESTRICTION IN A UNIVERSAL WORLD-FRAME

By Dr. GUSTAF STRÖMBERG

MT. WILSON OBSERVATORY, CARNEGIE INSTITUTION OF WASHINGTON

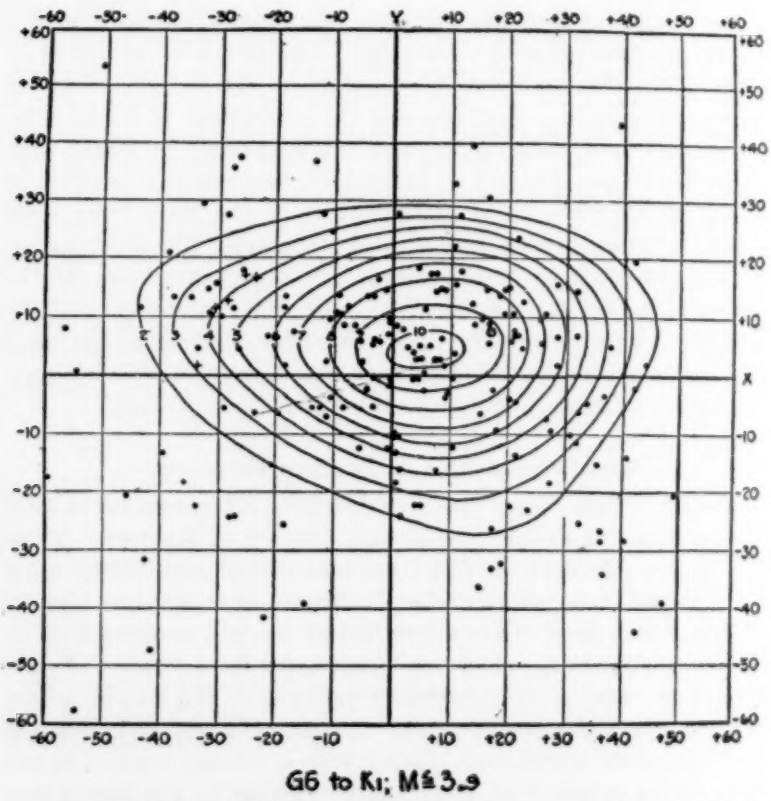
Our knowledge of the motions of the stars has increased considerably during the last decade. This has mainly been due to the determinations of radial velocities of a wide variety of objects and to the fact that stellar distances have been determined with a higher precision than has formerly been possible, particularly through the greatly increased accuracy in the determination of trigonometric stellar parallaxes and the application of the spectroscopic method of deriving the absolute magnitude of stars. The knowledge of the distances of individual stars makes it possible to determine the three velocity-components of the stars from their radial velocities, proper motions and distances. The most important results of these investigations are the confirmation of the ellipsoidal theory for the distribution of stellar velocities and the discovery of an asymmetry in the velocity-distribution, having a remarkable generality and regularity, which may be of importance for our conceptions of the properties of interstellar space.

The Distribution of Stellar Velocities

The ellipsoidal theory was introduced by Schwarzschild in 1908 as an alternative to the "two-stream" theory of Kapteyn. These two theories represent the distribution of stellar velocities by using two different frequency-functions. To obtain a general idea of what is meant by a velocity-distribution we will suppose that we have computed the three velocity-components for a number of stars in a certain system of coordinates, referred to the sun as origin. Imagine now a number of points all starting at the same moment from a common origin, each moving with a velocity parallel to and equal to that of one of the stars. After moving for one second they are all stopped; the points then form a cluster, the "velocity-cluster." The configuration of these points represents the distribution of velocities among the stars studied. In order to describe this cluster we will compare it with a body having a variable density, *e.g.*, a gas, called the "velocity-body," whose density represents the number of points per unit of volume. This density is proportional to the probability that all three velocity-components fall

within certain limits, or that a velocity-vector terminates in a definite volume of "velocity-space." The density in the velocity-cluster varies rather irregularly, especially if the number of stars is small, but we will suppose that within the ideal velocity-body it varies continuously from point to point. This variation in density is represented mathematically by a "frequency-function" or "distribution-law."

In a study of the motions of the stars of spectral classes F, G, K and M, made at the Mount Wilson Observatory two years ago,[1] a trigonometric series was used to represent the density in the velocity-body, and the result for giant stars of solar type (G6 to K1)



G6 to K1; M = 3.9

FIG. 1a. Velocity-distribution for giant stars of spectral types G6 to K1. The dots represent the velocities of individual stars, and a line from the origin to a dot gives, in direction and amount, the velocity of a star projected on the galactic plane. The sun is marked by a point within a small circle. The closed curves represent intersections of surfaces of equal density with the plane of projection.

[1] Mt. Wilson Contrib., No. 245, *Astrophysical Journal*, *56*, 265, 1922.

is shown graphically in Fig. 1a and b. The coordinate-system used is the galactic system, with the xy-plane coinciding with the great circle of the galaxy. The x-axis is directed towards the intersection of the galaxy and the celestial equator (in Aquila), the y-axis is in 90° galactic longitude, and the z-axis points towards that pole of the galaxy which is in the northern hemisphere. Surfaces of equal density (equifrequential surfaces) have been computed, and the intersections of these surfaces with the xy- and the xz-plane are the closed curves shown in the figures. The dots represent individual stars, and the line from the origin to a dot indicates, in direction and amount, the velocity of a star projected on the xy-plane in one figure, and on the xz-plane in the other. Only those dots are indicated whose lateral distances from the two planes of projection are small. As the sun itself is a star, wholly comparable with other stars in so far as its motion is concerned, we have not

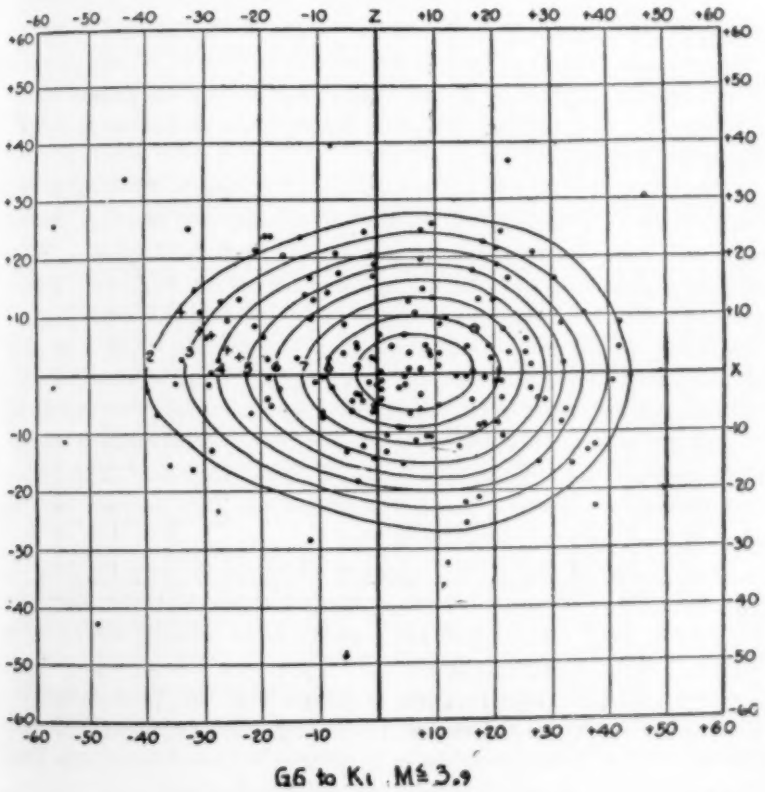


Fig. 1b. Same as Fig. 1a, but the plane of projection is here perpendicular to the galactic plane.

used in these figures the sun as origin, but have taken an algebraic mean of the three coordinates as origin. The velocity of the sun relative to the adopted origin is 20 km/sec. towards the point in the sky whose right ascension is 270° and declination + 30°. This is what we ordinarily refer to as the sun's velocity relative to the stars. The point which represents the sun in the two figures is indicated by a dot within a small circle.

From the diagram we see that the intersections between the equi-frequential surfaces and the xy- and xz-planes are in general elongated, closed curves, the elongation being along an axis which nearly coincides with the x-axis. The surfaces of equal frequencies are consequently not spherical, but elongated. If the equi-frequential surfaces had been concentric spheres, this would have indicated that the probability of a velocity, if referred to the center of the sphere, was independent of the direction of motion and dependent only on its size.

In Schwarzschild's distribution-law the dispersion is different along different axes and the distribution is characterized by an ellipsoid, the velocity-ellipsoid, the principal axes of which give the direction and amount of the maximum and minimum values of the dispersion. This velocity-ellipsoid corresponds to one of the equi-frequential surfaces.

According to the two-stream theory of Kapteyn there exist two interpenetrating groups of stars, the velocity-distribution within each one being represented by a spherical distribution-law. Were this hypothesis applicable we should expect to find two points around which the velocities would cluster, and the surfaces of equal frequency would either surround them separately or, in the case of the outer surfaces, surround them both. This, however, is not the case, as can be seen in Fig. 1. We have, instead, for the F, G, K and M stars at least, a single center and a configuration resembling that of the ellipsoidal theory of Schwarzschild. The major axis, however, coincides in direction with the line joining the two centers in Kapteyn's representation.

The study of the space-velocities of stars of spectral type A indicates the existence of three groups of stars, of which the most numerous, the "central group," has the same velocity-distribution as the F stars of high luminosity.[2] The other two groups, which, however, are not numerous, are identical with the Taurus and the Ursa Major groups, respectively; but can also be identified with Kapteyn's first and second streams, although these two streams have in general gone over into the ellipsoidal distribution.

The superiority of the ellipsoidal theory was first shown by Charlier in 1913. But several marked differences between the ob-

[2] Mt. Wilson Contrib., No. 257, *Astrophysical Journal, 57*, 77, 1923.

served and the calculated distribution were found, which indicated an inherent skewness, on the one hand, and an excess of large linear velocities, on the other. A further study of space-velocities has confirmed these deviations and has led to very remarkable results.

As seen in Fig. 1a the curves of equal frequencies are not symmetrical around the origin, the point of highest density lies in the first (upper right hand) quadrant of the xy-plane. This property has been found to be common to all giant stars, and shows that the mean of the x-, y- and z-coordinates is not identical with the most frequent values of these coordinates, as would be the case for a symmetrical distribution. This asymmetry can perhaps be best visualized by an inspection of the dots in Fig. 1a. The outlying dots do not form a symmetrical distribution around the condensation point, but show a marked tendency to avoid the first quadrant of the xy-plane. This asymmetry is especially marked if we limit ourselves to stars of high velocity. Fig. 2 represents the velocities higher than 100 km/sec. referred to the adopted origin. A line from the origin to a dot represents, in direction and amount, the velocity of such a star projected on the galactic plane. The velocities perpendicular to the xy-plane are fairly small and irregular, but the velocities in this plane show a marked asymmetry. Counting galactic longitudes from the positive x-axes (0°) over the positive y-axis (90°), we find that the points all lie between galactic longitudes 143° and

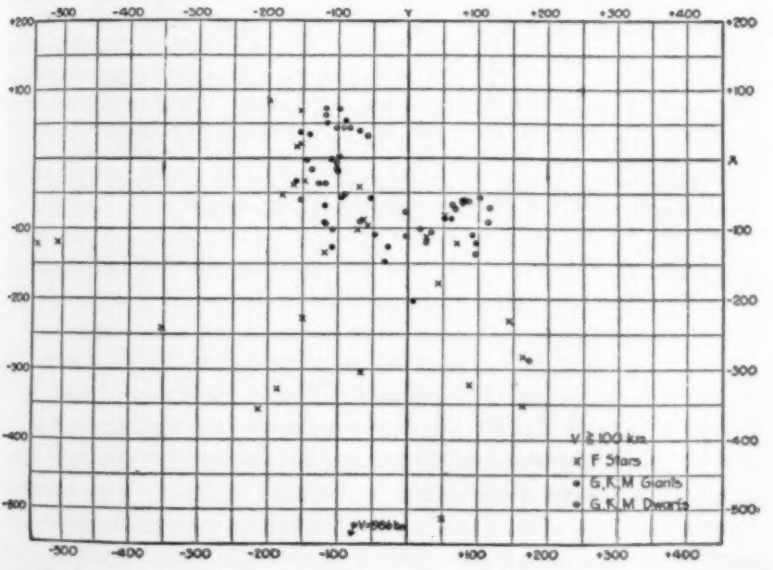


FIG. 2. Distribution of velocities higher than 100 km/sec. A line from the origin to a dot represents such a velocity projected on the galactic plane.

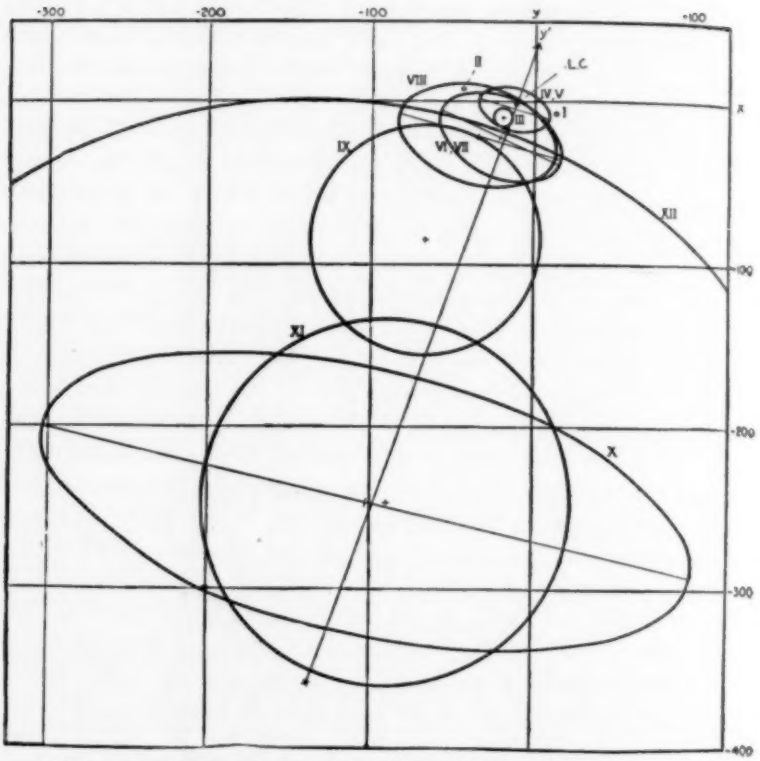


FIG. 3. Projection of the velocity-ellipsoids for different classes of stars and nebulae on the galactic plane. The sun is at the origin and the line from the origin to the center of an ellipse or circle represents the group-motion, relative to the sun, of that particular class of objects. The axes of the ellipses are equal to the dispersion in velocity within the groups. The systematic change in group-motion with increasing internal dispersion can be clearly seen. The line marked y' represents the direction of translation of objects with small divergence in motion relative to objects of large divergence.

334°, and that not a single one falls in the interval of longitude 334° to 143°, in other words, nearly all stars move towards the same hemisphere.

This asymmetry, which was first established by B. Boss, has recently been studied at the Mount Wilson Observatory,[3] and, with a certain reservation for the B-stars, has been found to be a very general phenomenon, existing among all classes of stars, and even among the distant star-clusters and spiral nebulae. Fig. 3 shows the results for a great variety of objects, with enormous differences in motion. The sun is now placed at the origin, and the line from the origin to the center of an ellipse or circle represents the group-motion, relative to the sun, of a particular class of objects, projected

[3] Mt. Wilson Contrib., No. 275, *Astrophysical Journal*, *59*, 228, 1924.

on the galactic plane. The principal axes of the ellipses represent, in direction and amount, the maximum and minimum values of the internal dispersion. If the dispersion is the same in all directions, or if the observations are insufficient to determine differences in dispersion, the velocity-figure goes over into a circle whose radius is equal to the mean value of the dispersion. Groups I and II are the Ursa Major and the Taurus groups, respectively, each one of which consisting of stars moving almost parallel to one another and within which the dispersion consequently is almost zero, so that the corresponding circles are very small. Group III consists of the B-stars; IV is the central group among the A-stars; V and VI are stars of spectral types F, G, K and M, the velocities of which are represented by two ellipsoidal distributions. The majority of stars in group V are giants, in group VI dwarfs; but, as the asymmetry exists for both these classes of stars separately, it was found advisable to represent the whole collection of objects by two distribution-laws. Group VII includes nebulae whose spectra show bright lines; and VIII, variable stars with bright-line spectra, the period of light variation being fairly long for these stars. Group IX is composed of variable stars with periods less than one day, the so-called cluster-type variables; X, of stars with excessively large velocities; XI consists of the globular star-clusters, and XII are nebulae with continuous spectra, most of which have spiral structure. The velocity-ellipsoids for the groups VII, IX, XI and XII are determined from the radial velocities, without the use of proper motions. The ellipsoids for groups IV and V on the one hand, and groups VI and VII on the other, are so nearly alike that they have been combined in order not to confuse the diagram.

We see clearly how the centers of the ellipses are shifted towards the third (lower left hand) quadrant as the internal dispersion increases. This means that the groups, regarded as units, move in a certain direction with a velocity dependent upon the divergence in motion of the stars within the group. The asymmetry in stellar motions is thus a phenomenon of great generality, and its explanation must be of fundamental importance for our conception of the mechanical laws which govern the motions of the stars. The ellipsoidal nature of the velocity-distribution, or what we usually call stream- or preferential-motion, is ordinarily explained as a result of the fact that the sun is not at the center of gravity of our local system, but removed from it, and that a preponderance of the stars move around this center.

A closer study of the distribution of velocities for the different classes of objects has shown that the relation between group-motion and the dispersion along the axis parallel to the systematic displace-

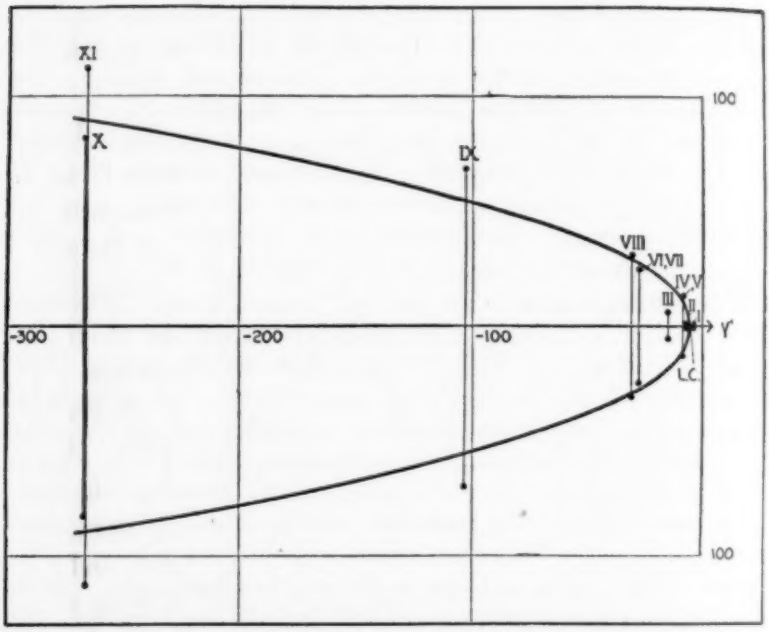


FIG. 4. Relation between systematic change in group-motion (abscissae) and dispersion along an axis parallel to this systematic shift (ordinates). This relation is represented by a parabola with its axis along the line of systematic displacements.

ment is very definite. This relation is graphically represented in Fig. 4 by a parabola, whose axis is parallel to the systematic displacement, the points in the figure indicating the agreement for the individual groups. Except for the B-stars (group III) the agreement is surprisingly good. An important fact is that the condensation-point in the velocity-distribution of stars of types F, G, K and M nearly coincides with the apex of the parabola, which represents the group-motion of stars of vanishing internal dispersion. This point is marked L. C. (limiting center) in Figures 3 and 4.

The existence of this relation between group-motion and dispersion leads to remarkable consequences. The velocity-distribution for all the cosmical objects studied can now be represented by a product of two frequency-functions, both symmetrical, but with different centers of symmetry. One of these centers corresponds to the top of the parabola, and the velocity of the sun relative to this point is 14 km/sec. towards the point in the sky $\alpha = 262°$, $\delta = +15°$. The opposite vector represents, in a certain sense, the most frequent stellar velocity. The velocity of the sun relative to the center of the second distribution, about 300 to 400 km./sec. in the direction

$\alpha = 323°$, $\delta = +60°$, is the same as its velocity relative to stars of maximum velocity, as well as its velocity relative to distant objects; these two latter velocities seem to be identical.

It has been known for some time that the velocity of the sun is different when referred to stars of different spectral types; and also when referred to stars of different apparent magnitudes. The sun's apex has a higher declination for stars of later spectral types and for stars of fainter apparent magnitudes than for earlier spectral types and brighter stars. Now it is known that stars of high intrinsic brightness and of early spectral types have the smallest peculiar motions. Since apparently faint stars are in general intrinsically fainter than the apparently bright stars, we see that the shift of the sun's apex is another aspect of the asymmetry, and that the limiting positions of the apex are nothing but the apices as referred to the two centers just mentioned.

We can explain the existence of two fundamental frequency-functions in the following way. If there is a fundamental system of reference in space of such a nature that very great velocities referred to this system are less frequent than smaller velocities, so that a "velocity-restriction" exists in this fundamental system, the effect on the motions in our local system of stars would be just that observed.

A simple example may help to illustrate the effect of such a velocity-restriction. Imagine a ship moving forward with great speed so that a strong headwind is blowing. On shipboard are several classes of individuals, all similarly affected by the wind, but having contact with the ship of different degrees of strength. We have then to do with two connections or velocity-restrictions acting at the same time on the different individuals, one limiting their velocities relative to the ship the other relative to the air. The first connection is represented by a velocity-distribution with its center attached to the ship; the center of the second distribution is at rest in the air. The members of the first group are supposed to be intimately connected with the ship and can move only very slowly relative to it; as a whole this group follows the ship in its motion. A second group consists of individuals who can move with greater freedom relative to the ship and consequently have a greater velocity-dispersion. Members of this class move faster towards the stern than towards the bow, and, if they do not take care, they may be blown off the ship entirely. The members of a third group have almost completely lost contact with the ship, or have contact only part of the time (*e.g.*, sea gulls); they can move fast in all directions and after a while form a group having a large velocity-dispersion, which, as a whole, is nearly at rest in the

air. A fourth group consists of other ships moving at random in all directions relative to the atmosphere. They have great velocity-dispersion and nearly the same group-motion as the third group. The velocities of these four groups can be represented by a series of velocity-distributions, whose centers are shifted in a certain direction, dependent upon the internal dispersion.

We see easily that all these groups are represented in our study of stellar motions. The relation between group-motion and dispersion which we have found, and which is represented by the parabola in Fig. 4, can be shown to be a necessary consequence of the combined effect of two connections or distribution-laws. One of these distributions is the velocity-distribution in the local system of stars, when no external velocity-restriction is acting; the other can be thought of as a "bond" between the individual stars and a cosmic system in which the globular clusters and spiral nebulae appear to be at rest in a statistical sense. In the following we will call this larger system the "world-frame." The first distribution probably represents an effect due to the fact that the stars in our local system have a common origin, with certain reservations, however, for the Ursa Major and the Taurus groups and the B-stars, which seem to form moving systems within the local system. As to the significance of the second connection we are more in doubt. In the following section we will discuss different explanations for the existence of this connection between the stars and the world-frame.

The Stars and the World-frame

We may imagine that the world-frame consists of a great field of stars, star-clusters and nebulae with respect to which our local system of stars has a velocity of about 300 km/sec. towards a point in the sky not far from the north pole of the ecliptic. It has been suggested that the proportion of stars belonging to the different types in the local system and in the world-frame changes steadily as we pass from group I to XII, and that, when we reach the three last groups in our series, we are dealing exclusively with objects belonging to the larger system. This hypothesis contains rather arbitrary assumptions and we should in this case expect to find a more marked change at the transition from one system to the other. Another possibility is that the different groups studied have originated in systems of different sizes and different motions relative to each other, the larger system giving rise to stars of higher relative velocities than those of smaller size. It seems difficult to reconcile the existence of a very *regular sequence* of groups with this hypothesis.

When stars belonging to two interpenetrating systems come near one another their mutual attractions influence their orbits, and the

ultimate effect of such encounters is that the dispersion perpendicular to the relative motion of the two systems is increased, while the translation is decreased in proportion to the increase in dispersion. It is remarkable, and it may not be accidental, that the stream-motion (major axis of the velocity-ellipsoids) is nearly perpendicular to the translation of the local system relative to the world-frame. On the other hand, however, the number of stars per unit of volume belonging to the larger system must be exceedingly small, and it seems almost impossible that the effect of encounters should have any appreciable effect at all. The conception of an enormous field of stars and nebulae seems to presuppose the existence of an organic connection between its parts, and this leads to the question: Why do not cosmic velocities exist that approach the velocity of light? The largest radial velocity as measured by Slipher is 1800 km/sec. (N. G. C. 584) and the transverse velocities probably do not exceed this value, provided we use an *inertial system* as reference-system for the proper motions.

If all cosmic objects have originated from the same system of gas or dust, we may imagine that some distribution of kinetic energy has taken place before the formation of the stars, and that consequently the velocity of a star, relative to the system as a whole, must be limited. We have reason to believe that the stars in our local system have a common origin, or have originated in several systems with fairly small velocities relative to one another. It has been found by Halm, and more recently by Seares, that there is strong indication of an equipartition of kinetic energy for the internal motions of certain classes of objects in our system. This can hardly be explained as an effect of encounters between stars, and seems to be due to initial conditions. Whether the remaining objects, including the most distant, have been included in this original system, or whether their motions have been affected by any distribution of kinetic energy before or after their formation, we do not know; but it is worthy of consideration that the distribution of velocities in the world-frame does not correspond to an equipartition of energy, for the individual velocities referred to the larger frame seem to be independent of mass. In fact, if we compute the mean velocity (in three dimensions) for the stars belonging to each of groups I to XI and refer these velocities to the world-frame, we find that they are all very nearly the same, namely about 300 km/sec; but the masses of the stars in the different groups vary considerably. This velocity may thus, in a certain sense be regarded as the mean "absolute" velocity of a star, even of those in the distant globular clusters. The mean velocity of the spiral nebulae referred to the same frame is about 600 km/sec, provided we have

the right to apply a systematic correction to the wave-lengths corresponding to an outward motion of about 700 km/sec.

In order to explain the absence of excessive cosmic velocities Einstein has assumed that the space-dimensions are curved, while the time-dimension is not curved, so that, for measurements on a cosmical scale, space is finite but unbounded. The inertial lines as well as the optical lines are closed curves. This leads to the conception of a fundamental system of space-coordinates in which all the matter in the universe is permanently at rest in a statistical sense. This assumption is, to a certain extent, a contradiction of the fundamental principles of the theory of relativity, but Einstein starts from the assumption that the metrical properties of space are *completely* determined by matter in space. It is thus conceivable that a coordinate-system in which the material universe is at rest has fundamental properties. Several scientists, among them the most ardent advocates of relativity, have expressed strong doubts that the fundamental metrical properties of space, such as the phenomena of inertia and the propagation of light, are *completely* dependent upon matter and gravitational fields, and that consequently these properties would be lost if the stars could be annihilated. If we follow Einstein we must assume, for instance, that the vibration-plane of Foucault's pendulum is held in position by the stars,[4] or their gravitational field; that a flywheel is torn to pieces by an action of the stars; that the nodes and loops of an electromagnetic wave are held in position by the stars (and consequently do not follow the earth in its rotation[5]); that the path of a beam of light is not only deflected by passing near a star, but that the very possibility of light propagation is dependent upon the existence of the stars.

If we assume, however, that space or space-time has fundamental properties independent of the existence of the stars, and that these properties are only modified in the neighborhood of matter (which modification can be regarded as equivalent to a gravitational field), many of the difficulties disappear. The three-dimensional nature of space and of solid bodies, the one-dimensional nature of time, the constant velocity of light and the existence of inertia can be regarded as such fundamental metrical properties.[6] The limitation of cosmical velocities may possibly be connected with a fundamental property of space, which prevents the material cosmic system from "evaporating," and gives the stellar frame a certain degree of

[4] The "stars" mean here and in the following the sum total of all matter in the universe.

[5] An experiment to test this has been suggested by Silberstein and is now being performed by Michelson and Gale.

[6] Even a curvature of space and time has been regarded by De Sitter as an absolute property independent of the matter in the universe.

rigidity. The coincidence, so far as rotation is concerned, between the stellar frame and the inertial frame is a necessary consequence of such a velocity-restriction.

These considerations call our attention to the classical conception of the ether as a space-filling medium, giving space its electromagnetic properties. The theory of relativity does not compel us to deny the existence of such a medium; on the contrary, the four-dimensional space-time has been identified by Einstein with the ether, which he regards as necessary in order to understand the existence of "absolute" rotation and acceleration. We quote Einstein's words in his Leiden Lecture of 1920:[7]

> Newton might no less well have called his absolute space ether; what is essential is merely that besides observable objects, another thing, which is not perceptible, must be looked upon as real, to enable acceleration or rotation to be looked upon as something real.

The reference-frame for "absolute" acceleration or rotation can be called "ether" or "space-time," or a "field of geodesics" (Eddington), or the "metrical field of space" (Weyl), and it can be "materialized" by light rays or moving particles ("world-lines"). The earth rotates relative to a metrical field, in which the stars are nearly at rest in a certain sense, which is the same as Newton's conception. On account of the existence of this metrical field the earth's motion around the sun and the sun's motion around the earth are not equivalent, as evidenced by stellar aberration, stellar parallaxes, and the yearly variation in the radial velocities of *all* the stars, which phenomena do not exist for an observer on the sun, or rather at the center of mass of the solar system. Weyl[8] has pointed out that without this metrical field, the conception of one body moving relatively to another body, separated from the first, would be entirely meaningless. The remarkable thing is that this metrical field is ambiguous with regard to uniform motion of translation.

An interesting analogy has been pointed out by Einstein in the lecture just quoted. When we study waves on the surface of the water, it is the propagation of the waves which we observe, and not the motions of the water-particles themselves. If the existence of floats in the water were a physical impossibility, we would have no means whatever of studying the motions in the water, and our description of the motion would be of such a form that the motion of the individual particles does not enter into it. The nearest approach to observable floats, moving with the least dependence on one another, seems to be the stars, which can be regarded

[7] "Ether and the Theory of Relativity," Sidelights on Relativity, Methuen, 1922.

[8] "Massenträgheit und Kosmos," *Die Naturwissenschaften, 12,* 197, 1924.

as influenced by a number of impulses. Prominent among these impulses are the gravitational forces, but there may be others; and even the most feeble impulse, if acting in the same direction during billions of years, may have an effect upon the motion, and we can thus regard the stars as indicators, extremely sensitive for secular effects. We can not study a star during any very long time, but we can study the present velocity-distribution, and we can make assumptions about the original distribution. The study of stellar motions indicates that space, or something in space, has the property of exercising a restricting influence on stellar velocities relative to a system of coordinates that seems to be the same everywhere, *i.e.*, it is stationary. The mechanism of this restriction is unknown, but the asymmetry in stellar motions indicates that it is a gradual process. It seems possible that there exists some sort of reaction during the process of radiation, when the connection between an electron and the ether is of another and more intimate nature than when the electron is not radiating. In the latter case the conception of absolute motion seems to be meaningless, but we can not be quite sure that this is the case for a radiating electron.

At all events, if there exists a space-filling medium we should expect to find some effects of it on stellar motions, even if these effects are entirely too small to be noticeable in laboratory experiments. The existence of a fundamental velocity-vector, as that defined by the asymmetry in the velocity-distribution, points to a property which can be most simply explained as a translation relative to a fundamental and universal system of reference. That this velocity-vector agrees with the translation of our sun relative to very distant objects, at least in so far as it is possible to determine this translation from the present data, gives additional justification for this interpretation.

We can express this in another way. When we refer the motion of a body to systems of larger and larger dimensions, we find that we have to stop at the system of clusters and spirals, not only for the reason that we can not observe more distant objects, but also for the reason that this cosmical system seems to have certain physical properties and not merely statistical qualities.

PARASITISM AMONG THE INSECTS

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AMONG the insects, parasitism may be considered either a widespread and, indeed, fundamental habit of life or a comparatively rare and recently acquired one, depending on our viewpoint. It is evident at the start, then, that before proceeding to discuss insects as parasites we must determine just what limits our subject shall have.

As a generally accepted definition of a parasite we may take that of Braun, translated as follows by Fantham, Stephens and Theobald: "Parasites are living organisms which, for the purpose of procuring food, take up their abode, temporarily or permanently, on or within other living organisms." Essentially the same idea, with one valuable addition, is expressed in Webster's Dictionary: "Parasite—a living organism which lives on, in or with some other living organism from which it derives nourishment."

One further quotation from Fantham, Stephens and Theobald is perhaps germane to our discussion, since it shows more clearly just how Braun himself interpreted his definition: "Occasional parasites, such as the flea, the bedbug, the leech and others, only seek their host to obtain nourishment and find shelter while thus occupied."

Our usual idea of a parasite, then, may be summed up in the following five statements, of which the first two are essential characteristics of all parasites, while the last three are of secondary importance and, as we shall see later, do not hold true for all parasitic forms.

A Parasite *always*—

(1) lives on, in or with some other living organism.

(2) derives its food from this other living organism, which we call its host.

As a rule, a parasite also—

(3) is smaller and weaker than its host.

(4) does no serious injury to its host (in the case of True Parasites only).

(5) often shows ("degenerate") structural adaptations for its parasitic mode of life.

As far as the insects are concerned, the two essential characteristics may be somewhat amplified. In the first place, a parasite lives on, in or with its host, and may do either *permanently*, like

the lice, which even glue their eggs to the hair or feathers of their host, or *temporarily*, like the bot-fly, whose larva lives in the stomach of a horse, but which pupates in the ground and has a free-living adult stage, or like the flea, which visits its host periodically for blood as an adult and may even spend much of its adult life on the host's body, while its larval stages live happily on in dust and débris whether the host is near at hand or far away. Or, finally, a parasite may live on its host only *occasionally*, like the mosquito, which visits the host only for the brief period necessary to obtain a meal of blood.

At first sight, I admit, it seems far-fetched to consider a mosquito as a parasite. But where are we to draw the line? Consider such a series of insects as this:

(1) A wood mosquito (*Aedes*), which will feed on blood when opportunity offers, but is entirely capable of completing its life cycle without it.

(2) A malaria mosquito (*Anopheles*), which visits houses to obtain blood and is unable to develop eggs without it.

(3) A yellow fever mosquito (*Stegomyia*), which not only visits houses for blood, but lives and breeds in and around houses, as well.

(4) A bedbug, which lives and breeds in houses, visits human beings for blood, and shows degeneration of its wings.

(5) A flea, which breeds in houses (or in the nest of its host), has lost its wings, which visits the host for blood and may remain on the host longer than is necessary for feeding alone.

(6) An ordinary louse-fly (*Hippobosca*, for example), which normally lives on the body of its host and feeds on its blood, but retains well-developed wings and occasionally leaves the host for a flight through the air.

(7) A wingless louse-fly (such as the "sheep tick," *Melophagus*), which always lives and feeds on the body of its host, just as a louse does.

Where, in such a series as this, can we draw a sharp line and say, "Here the parasitic mode of life begins?" Or, to take another example, who would deny the name of parasite to a tick? Yet the majority of ticks do exactly what a mosquito does, that is, they visit their hosts only for a period necessary to obtain a meal of blood. The only difference is that while the mosquito is able to engorge completely in a few minutes, the tick may require days or even weeks. But when engorgement is complete, off drops the tick, and proceeds to digest the blood-meal and either moult or lay its eggs in a strictly free-living condition.

To cut a long argument short, to me, at least, the most logical and expedient way of deciding the question seems to be to include even the extreme cases under the general heading of parasites.

In the second place, a parasite derives its food from its host. I do not wish to become entangled in a discussion of symbiosis, commensalism, and so on, because most of the cases classed under these and other heads have been so imperfectly investigated that one who

argues for or against their existence is too often driven to rely on imagination in lieu of facts. It is worth while to point out, however, that while most parasites either feed on waste material of little or no value to the host, or else abstract amounts of blood or other body fluids which are negligible in the case of any single parasite individual, there are some parasites which seem to be of definite use to their hosts and there are also others which are definitely harmful, which, for example, actively devour the host tissues and may even kill the host in this way.

And I must also mention the insects which Wheeler calls "social parasites," since they parasitize a colony instead of an individual and contrive to obtain their food and that of their larvae from the supplies brought in by the working members of the colony.

As to the secondary characteristics of parasites, the statements that a parasite is usually smaller and weaker than its host and that it often shows what have been called the "stigmata of degeneracy" in the line of structural adaptations for its mode of life, probably need no further comment. As to whether a parasite is normally injurious to its host or not, it is necessary to notice the existence of two sharply conflicting viewpoints.

The biologist, taking a general view of the immense series of parasitic organisms, and noting that only in rare and exceptional cases does obvious injury to the host result from the activities of the true parasites, naturally considers that cases where the parasite does injure the host represent instances of incomplete adaptation. He would point out, for example, that even among the trypanosomes, to pick out a group whose very name brings to our minds a vision of deadly disease, we know many more species which are innocuous to their chosen hosts than we do injurious species. And it is even thought that the species most deadly to human beings are accidental introductions into man and are themselves harmless to their original hosts.

On the other hand, the physician, usually knowing nothing of parasites except the symptoms which some of them produce in human beings, is, of course, prone to believe that the injury of the host is an essential property of a parasite, and to declare that even when we can see no injury one must nevertheless be present.

But now to return from this digression on the definition and main characteristics of a parasite to my original statement, that parasitism could be considered either a wide-spread and fundamental or a rare and recently acquired habit among insects. You will no doubt have noted that all the definitions specify that a parasite lives on or in "another living organism" and derives its food from it. We can not deny that plants are living organisms, and

so at one stroke the great majority of vegetarian insects become parasites. There are, it is true, certain insects which feed on small plants and devour them whole, and may thus be considered as predators on the vegetable kingdom. But the great mass of plant-feeders, including those who eat the leaves, those who suck the sap, the borers, the miners and the gall-makers, must be considered parasitic in their mode of life. In this sense, parasitism might be considered the fundamental mode of life among insects, grading into the saprophytic habit on the one hand and into the predaceous on the other.

But although the plant-feeding habit does come within the definition of parasitism, it is not with that side of the problem that I propose to deal. Ordinarily, when we speak of insects as parasites, we are thinking of those insects which parasitize other *animals*. In this sense, parasitic groups of insects are comparatively rare, and most of them have evidently acquired this habit of life rather recently. Indeed the greatest interest in the study of insect parasitism lies in the study of the intermediate forms which still survive in some cases, to show us how this habit of life came to be adopted.

Among the various groups of insects which are loosely referred to as parasitic we may distinguish three different types, which, following Wheeler, we can conveniently term the true parasites, the parasitoids and the social parasites.

To discuss these three groups in turn, the *true parasites* include those insects which we parasitologists, with our medical affiliations, naturally think of when parasitic insects are mentioned. They conform to our definition in all respects. This group takes in all the lice, both Mallophaga or "bird-lice" and Siphunculata or true blood-sucking lice, all the Siphonaptera or fleas in their adult condition, and a considerable number of distinct groups of the Diptera or flies, such as the ectoparasitic Hippoboscidae or louse-flies, the larvae of the Oestridae or bot-flies, a number of other fly larvae and the whole array of blood-sucking flies, from a tiny sand-fly, Phlebotomus, to the bulky Tabanidae or horse-flies and the vicious tsetse, Glossina. It also includes the few blood-sucking species among the Hemiptera or bugs, such as the bedbugs and the "barbieros" (Triatoma) of the tropics, as well as a few other insects less familiar to us, the tiny bee-louse, Braula, for example, the beaver-beetle and the peculiar little wasp-parasites included in the Strepsiptera.

Since these true parasites are the insects which form the subject-matter of medical entomology and are thus better known to parasitologists than some of the other groups, they may be dismissed with comparatively brief mention. They may be grouped or sub-

divided in various ways. Most commonly, perhaps, we find them classified according to their position in reference to the body of their host. Thus we distinguish external parasites, either occasional, temporary or permanent, and internal parasites, which among the insects are always temporary, that is, always have both a free-living and a parasitic stage in their life-cycle.

Of more importance from the standpoint of disease causation and transmission is a grouping according to the food-habits. The majority are blood-sucking forms, but some fly larvae (Oestrus, etc.) seem to feed on the serous exudates which their presence provokes, others (Gasterophilus, etc.) absorb partially digested food from the stomach, and a few, like the notorious screw-worm (Cochliomyia), actually devour the living tissues. Other fly larvae and most of the bird-lice might be called parasitic saprophytes, since they feed on waste material from their host, either in the intestine or on the body surface.

It is obvious that this parasitic mode of life must have arisen independently in these various groups of insects. And, as we should expect, it has not always arisen from the same foundation. A few examples will illustrate this.

In the Hemiptera or bugs the original food was evidently the sap of plants, and in order to obtain this the bugs have developed a very effective piercing and sucking beak. Some of the Hemiptera, the majority of the family Reduviidae, for example, have discovered that this beak will serve equally well to extract the juices from smaller insects, and have thus become predaceous. And, finally, a few Reduviids, such as the species of the genera Triatoma and Rhodnius, have found that still larger animals, the lower mammals, contain just beneath the skin and within easy reach of the hemipterous beak a nourishing fluid, the blood. Some of these species have even dared to transfer their affections to man himself, when opportunity served, unfortunately carrying with them the trypanosome parasites of their former hosts, which proved so ill adapted to the human body that they produced the disease discovered by Dr. Carlos Chagas, and often known by his name. Here we have the unusual spectacle of a change in feeding habit from plant parasitism, through a predaceous habit to parasitism on lower animals and finally on man, without any essential modification in the organs by means of which food is obtained. The bedbugs probably acquired this habit of life in much the same way as the Triatomas.

Among the flies, the blood-sucking habit has arisen a number of different times and, seemingly, in several different ways. In the mosquitoes it may have arisen directly from a plant-feeding habit.

All male mosquitoes, and in a few genera the females also, feed only on the juices of plants. Even the normally blood-sucking females will feed with avidity in nature on a juicy watermelon rind, and in the laboratory they can be kept alive for months on a diet of water-soaked raisins. Essentially the same condition is to be seen in other groups of flies in which the females alone suck blood, such as the black-flies and horse-flies (families Simuliidae and Tabanidae). In all these groups the habit of feeding on vertebrate blood seems to be a response to the need for a large supply of unusually nutritious food to enable the female to develop large numbers of eggs. But no intermediate forms now remain to tell us just how these females came to discover that blood offered such an accessible and nourishing food supply.

In the blood-sucking midges (Ceratopogoninae) it seems likely that this habit of life evolved through a predaceous stage. While the majority of midges feed on nectar and other plant juices, some of the Ceratopogoninae have developed the habit of frequenting flowers, not to feed on their juices, but to prey on the smaller flies which are attracted to them. Other species of the same group have taken the short step between sucking all the juices of smaller insects and sucking a portion of the blood of larger insects. And finally we have a hint as to how the transition to a diet of vertebrate blood *might* have occurred in the case of a single species of the blood-sucking genus Culicoides. This species, *Culicoides anophelis*, does feed on blood, like most of its relatives, but it obtains its blood-meal by driving its proboscis into the swollen abdomen of an engorged mosquito.

In a small group of Muscoid flies, the blood-feeding habit is common to both sexes. Here we find an exceptionally interesting series of forms, showing not only the acquisition of the blood-sucking habit but also the gradual modification of the fleshy, spongy proboscis of the house-fly into the slender, piercing stiletto of the tsetse. In this group we also find, rather surprisingly, that the blood-feeding habit has become well developed in certain species before any mechanism for piercing the skin and obtaining the blood is available.

The common house-fly, *Musca domestica*, is almost omnivorous. It feeds on any nourishing material which is in liquid form or can be liquefied by the regurgitation of fluid from the fly's crop. While we usually think of a fly as feeding on human foods, on garbage and on liquid filth, it will also take blood or serum when they exude from the body or are otherwise exposed, as any one who has tried to dry blood-smears in a fly-ridden room can testify. Certain other species of Musca have adopted this latter diet exclusively. Lacking

a piercing proboscis themselves, they frequent cattle or horses, awaiting the arrival of a blood-sucking Tabanid or Muscoid fly. As soon as such a fly has pierced the skin it is surrounded by a ring of these Muscas, which crowd and hustle it, sometimes forcing it to withdraw its proboscis and seek a meal elsewhere. When the blood-sucking fly has finished its meal or has been persuaded to depart, the Muscas eagerly surround the site of the puncture, lapping up the surplus blood which trickles from the wound.

Other closely related flies, usually placed in the genus or subgenus Philaematomyia, go a step farther. Their probosces are still of the same general form as in Musca, but the base is more heavily chitinized, the spongy labellae are smaller, and the prestomal teeth, which in the house-fly are very minute, are here much larger and form a fairly effective rasp or file, by means of which the fly is able to wear away the epidermis until the capillaries are ruptured and blood flows out to be lapped up by the spongy labellae.

In the more highly specialized blood-sucking genera of this group the proboscis becomes more and more slender, more and more heavily chitinized, and the labellae are ultimately reduced to tiny lobes just large enough to bear the large prestomal teeth. Theoretically, this proboscis still works like a rasp, but so tiny are the rasping surfaces and so rapid the action of their muscles, that to the naked eye the proboscis appears to be merely pushed into the epidermis as one might push a pin.

In such permanent ecto-parasites as the lice, the parasitic habit seems to have arisen from a saprophytic mode of life. The best authorities now believe that the bird-lice and the blood-sucking lice are closely related, perhaps representing branches which have arisen from the same common stock and have become specialized in somewhat different directions. Forms which may be close to the original stock from which the lice arose are still in existence under the name of book-lice. The best known of these little creatures is the species which is so often found in old books, or eating up museum specimens or even attacking starched clothing. Others are to be found in the nests of birds and mammals, eating all sorts of débris, including, of course, the cast-off feathers or hair. It is easy to imagine such a species forsaking the nest for the body of the host itself, still feeding on feathers, hair or bits of dead skin. A few minor structural adaptations would then give us a bird-louse. At some time early in the development of bird-lice, some of them must have discovered the great reservoir of nourishing blood just beneath the skin and developed piercing mouthparts for the purpose of tapping it. We can even make a crude approximation of the date of this historic moment in the annals of the lice, for, so

far as we know, those primitive mammals, the marsupials, are infested only by bird-lice, while every other large group of mammals has developed its own characteristic groups of blood-sucking lice. It is possible, then, that these latter originated after the marsupial stage of evolution had been left behind, but before the primitive stock of the higher mammals had undergone any further extensive subdivision.

Many of the parasitic fly larvae seem also to have come from saprophytic ancestors. In the blow-fly group, for example, the majority of the larvae live in decaying meat. Many different species of these flies will occasionally deposit eggs in neglected wounds, both of domestic animals and, more rarely, of human beings. In time of war, when wounded men are often forced to lie out on the battle-field for hours without medical attention, such cases of wounds infested with fly larvae become common. Although almost any of the blow-flies may thus have occasional parasitic larvae, there are a few species which have become notorious because of the frequency with which this occurs. In America, for example, the larvae known as screw-worms are frequently found parasitizing both domestic animals and man, sometimes with very serious and even fatal results. Within very recent years, also, a number of blow-flies have developed the habit of laying their eggs on the soiled wool of sheep, and the larvae which hatch from these eggs may attack the skin and other tissues as well as the wool. These "wool-maggots" probably present the gravest problem to-day in Australia, but various American and European blow-flies have also adopted this habit to a considerable extent.

And finally, besides these blow-flies in which parasitism has become more or less habitual, a few species of blow-flies and flesh-flies have recently been found to be obligate parasites in their larval stage. The best example of these is probably *Chrysomyia bezziana*, an Oriental and African species fairly closely related to our screw-worm fly. Colonel Patton has found that an overwhelming majority of the larvae sent in to him from cases of human and animal myiasis in India belonged to this species, and he was unable to rear these larvae to maturity in decaying meat, the original larval food of all the blow-flies. As soon as the meat began to decay, these larvae all died, and it was finally found necessary to transfer the larvae every day to a freshly killed rabbit carcass in order to enable them to reach maturity and pupate.

All the blow-fly larvae are obviously recently developed and poorly adapted parasites, since they always injure their host and sometimes seriously threaten its life. But from a beginning like this, sometime far in the past, there may have developed one section

of the bot-flies, in which we find the larvae living under the skin or in the head sinuses of various mammals, not destroying the host tissues, but merely feeding on the exudations called forth by their irritating presence.

So much for the true parasites among the insects. Now when any entomologist except a medical entomologist refers to parasitic insects, it is extremely likely that he is thinking, not of the true parasites, but of the *Parasitoid* parasites. Most of the truly parasitic insects parasitize vertebrates. The tiny "bee-louse," a degenerate fly which is a true external parasite of drone honey-bees, is one of the few known exceptions to this rule. In nearly every case, then, the insects which parasitize other insects are of the parasitoid group. When an economic entomologist, for example, speaks of the possibility of controlling some insect pest by means of its parasites, he is referring to these parasitoid parasites.

These parasitoid species differ from the true parasites in several ways. In the first place, the parasitoid condition is always one of temporary parasitism. In the insects, a parasitoid species is always parasitic as a larva and free-living as an adult. Further, the parasitism of a host individual by one or more parasitoid larvae almost invariably results in the death of that host individual. The parasitoid condition is, in fact, one of a long-drawn-out predaceous existence. As Wheeler has said, the so-called parasitic Hymenoptera are really very economical predators. The female deposits her eggs or larvae on or within the body of some other insect, larval or adult. The parasitoid larva then starts in to eat up its host *in toto,* but it cannily begins with the fat-body and other tissues not essential to the life and growth of the host. Thus the host may continue for a long time to live and grow apparently normally, and may even reach maturity and pupate, in the case of a larval host. But the end is certain, though delayed. Sooner or later, when the non-essential tissues are all consumed and the appetite of the parasitoid larva whetted thereby, the essential tissues as well are devoured, until nothing remains of the host but an empty skin, which the parasitoid larva often utilizes as a convenient and protected place for its own pupation.

Such parasitoid larvae are particularly characteristic of a number of families of the higher flies and of the great assemblage of parasitic Hymenoptera known as the Ichneumon flies and their relatives. It seems obvious that this habit has been separately developed in the Diptera and in the Hymenoptera, and it is probable that it has been separately developed on a number of different occasions in each of these orders.

Although my acquaintance with these parasitoid groups is very superficial, I will be able to bring out a few of the many interesting features of their characteristics, their adaptations for this mode of life and its possible origins. It is interesting to find, in the first place, that in the majority of cases there is a decided difference in the manner of oviposition in parasitoid Diptera and parasitoid Hymenoptera. In the latter we find a complex, piercing ovipositor, which, of course, becomes the sting in the higher bees and wasps, and is then used for quite another purpose. In the parasitoid Hymenoptera, this ovipositor is generally used to implant the eggs within the body of the larval host. Most of the parasitoid Diptera have no ovipositor or, at best, a "pseudo-ovipositor" like that of the common house-fly, designed for the accurate placing of the egg, but not adapted for piercing. They, therefore, are obliged to lay their eggs or deposit their larvae on the outer surface of the host, leaving the actual penetration to the activity of the larva itself.

These parasitoid insects offer a wonderful field of study to any one interested in complex and often beautifully adaptive life histories, as well as to the workers in economic entomology. While a great deal of information has been accumulated on the taxonomy and the host preferences of these species, very few complete life histories have been worked out, compared with the vast numbers of genera and species included in these parasitoid groups. Almost every serious piece of work on these insects has disclosed some very remarkable examples of adaptive instincts. As every one knows, the Bureau of Entomology has spent a great deal of time and money in introducing parasitoid enemies of the gypsy moth caterpillar into this country. Some of the life histories worked out in connection with this work of parasite introduction are most interesting.

I have already remarked that most of the parasitoid flies lay their eggs or larvae on the outer surface of the host. This habit is not universal, however, and among the gypsy moth parasites some extremely interesting variations from this practice have been found. Any one who has watched a caterpillar feeding on a leaf will recollect how it eats in little semi-circles, biting off small bits in regular order along the whole circumference and then returning to the starting point to begin snipping off another series. Certain of the flies whose larvae parasitize the gypsy moth caterpillar take advantage of this habit by laying their minute, hard-shelled eggs on the moist, freshly cut edges of the leaves, where the caterpillar is likely to bite them off and swallow them on its next round.

Other caterpillars have the habit of leaving behind them as they crawl over a leaf a slender, silken thread, which seems to serve as a blazed trail for their return trip, since they often return later along the same track, guided perhaps by the thread itself, perhaps by some odor emanating from it. Some of the flies whose larvae parasitize these very hairy caterpillars have the habit of depositing their young larvae along these silken trails, the larva being supported in an upright position by a little membranous cup attached to the leaf. This may result in the larva's being able to attach itself to the unguarded ventral surface of the caterpillar when it returns over its previous track.

The work of the gypsy moth laboratory has also revealed some very interesting life histories in the parasitoid Hymenoptera. Many of these latter are what are called "hyper-parasites," that is, their larvae lead a parasitoid existence in another insect larva which is itself a parasitoid. In one such case, the earliest stage of the larva of the Hymenopterous hyper-parasite was found, not in the body of the parasitoid fly larva which is its usual host, but in the caterpillar which serves as host to the fly larva. The young larva of the hyper-parasite searches actively through the whole body of the caterpillar until it finds one of the parasitoid fly larvae, it penetrates into the body of the fly larva and then, surprisingly enough, becomes quiescent and floats passively about in the blood which fills the maggot's body cavity, without feeding or increasing in size. This state of affairs lasts until the fly larva has devoured all the available tissues of the caterpillar, has become mature and has pupated. Then it soon appears that all its eating was of no avail to itself, for the larva of the hyper-parasite, probably stimulated by the beginning of the process of histolysis which accompanies pupation, emerges from the pupa and begins to feed on it externally, by sucking out the pus-like fluid to which most of the tissues of the pupa are reduced at this time. Although the pupa may remain alive for some time, it seems to cease its development as soon as the larva of the hyper-parasite begins to feed. Ultimately the fly pupa, like the caterpillar before it, is reduced to a sac of thin membranes and the full-fed larva of the hyper-parasite pupates within the empty puparium.

Leaving these few cases to serve as examples of the peculiar adaptations of some of the parasitoid life histories, let us ask about the origin of the parasitoid habit of life. Probably it has arisen many different times in several different ways.

Among the parasitoid Diptera, there are a number of families all of whose species have adopted this habit of life, and which therefore give little or no light on the origin of the habit. In the

Sarcophagidae, or flesh-flies, however, are found both free-living and parasitoid larvae. It seems likely that the flesh-flies are derived from the blow-fly group of the Muscidae, therefore we may look on the larvae which feed in decaying meat as the primitive type. Some Sarcophaga larvae feed in fecal matter, perhaps representing a reversion to the ancestral habitat of the primitive Muscoid stock from which the blow-flies may have originated. Others have become truly parasitic in wounds and skin lesions of vertebrates, in the same way that some of the blow-fly larvae have done. Still others have shifted from decaying meat to the dead bodies of insects and other invertebrates, and it is probably from this branch that the parasitoid species of the genus have evolved.

In the parasitoid Hymenoptera, certain habits lead us to suspect that the origin of this habit of life was linked up in some way with a predaceous habit in the adult. The females of many different groups of the parasitoid Hymenoptera feed on the blood which exudes from the punctures made by their ovipositors. Some, whose larvae are parasitic in the hard-shelled puparia of the higher flies, are even known to gnaw a hole in the puparium with their mandibles, feed on the exuding juices, and then run their ovipositors in through the same aperture to deposit their eggs. Such observations show that the instincts of feeding and of oviposition are very closely connected in these insects, and suggest that the habit of ovipositing in other insects arose because of the predaceous feeding habits of the adults.

Other parasitoid forms may well have come from groups which parasitize plants. The Cynipidae, or gall-flies, for example, are a group of Hymenoptera in which the female, as a rule, inserts her ovipositor into plant tissues and deposits her egg there. Either the presence of the egg and later of the larva, or perhaps the presence of some fluid deposited with the egg by the female, so irritates the plant tissues that pathological growths known as galls are produced, within which the larva lives and feeds. As I have already pointed out in the case of the Hemipteran beak, organs which insects have developed for piercing plants are usually adequate for piercing the skins of insects and other animals as well. There is, in fact, a small group of Cynipid Hymenoptera, with the same essential structure as the others, whose larvae live in the characteristic parasitoid manner within the larvae and pupae of our common flies.

Beside the interesting question of the origin of the parasitoid Hymenoptera, this group is of great interest because it is believed that the social Hymenoptera have developed from such parasitoid ancestors. In his recent book, "Social Life among the Insects,"

Dr. Wheeler has developed this thesis at some length, particularly as regards the solitary wasps, which he considers as furnishing the connecting links between the parasitoid and the social forms. Some of the more primitive solitary wasps are really parasitoids, laying their eggs, in some cases, on the bodies of beetle larvae in their underground burrows. Some of these digger-wasps (genus Tiphia) are said to use their sting as a hypodermic needle rather than as a dagger, since the paralysis resulting from the sting lasts only an hour or so, serving merely to anesthetize the grub and render it motionless while the wasp deposits her egg. Other solitary wasps produce a permanent paralysis with their stings, and in some cases the females themselves feed on the paralyzed grubs for several days before laying their eggs on them.

It is rather a delicate question whether the mere act of stinging the victim into paralysis before depositing an egg on it is sufficient to set up any rigid distinction between the parasitoid type of existence and that characteristic of the majority of the solitary wasps. However, most authors do not speak of such a wasp as a parasite, but rather as a skillful huntress, providing for her young.

From searching out the burrows of larvae in wood or earth, stinging them and ovipositing in situ, it is an easy transition to the digging of a burrow of the wasp's own or constructing a cell or series of cells of earth, paper or leaves, and provisioning this "home" with one or a number of paralyzed insects for the larva to feed on. Then we could cite such wasps as Bembix, which leave the burrows open and feed their larvae, day by day, with paralyzed flies. Other similar species prepare the food still further, feeding the larvae with pellets formed from chewed-up caterpillars. Next would come the cooperation of several pairs of wasps in constructing a common nest or comb, and finally the true social wasps, whose colonies each consist of the progeny of a single female, and begin much like those of the higher solitary wasps, but differ in that the majority of the progeny are females which are not completely developed sexually. These under-developed females (workers) remain with the mother and assist her in caring for future broods.

Among the social insects, as among human societies, there occur individuals which contribute nothing to the colony, yet derive their food from it. These Wheeler calls *Social Parasites*. Perhaps we should include in this category as well the so-called parasitic species among the solitary wasps, which construct no cells of their own and do not hunt and paralyze prey, but provide for the future of their progeny by placing their eggs in the cells which have been constructed and stocked with food by some other species of wasp. In some cases the egg or larva which originally inhabited the cell is

bundled out to starve, in others the larva of the parasite devours not only the stored provisions but the original occupant as well.

Cases of true social parasitism, where one species lives in a colony of another species and deludes this colony into both feeding the adult and caring for the progeny of the intruder, are known in hornets, bumblebees and other social Hymenoptera, but the most interesting cases occur in the ants. Since I wish to avoid any discussion of the types of parasitism usually classed under the heads of symbiosis, mutualism, commensalism, and so on, I will make no attempt to deal with the numerous insects of other orders which are tolerated in the nests of ants and termites. I do think it may be valuable, however, to briefly review Wheeler's discussion of the three types of true social parasitism which he recognizes in ants, namely, the slave-makers, the temporary social parasites and the permanent social parasites.

The so-called slave-making ants have long been noted for their habit of raiding other ant colonies, carrying off larvae and pupae, and incorporating the workers which emerge from these larvae and pupae into their own colony. Wheeler has shown that this habit is of very real value in the founding of the colony of the slave-makers. In these ants the young queen seems to be absolutely incapable of rearing her first brood of workers without assistance, so it is essential that she secure workers from some outside source to aid her in starting her colony. The young queen of the "blood-red slave-maker" (*Formica sanguinea*) invades a colony of the larger, black *F. fusca* after her marriage flight, appropriates a pile of pupae, and is adopted by the black workers which emerge from these pupae. The young queen of the "amazon" ants (Polyergus) takes an even more direct method of securing alien workers. She invades a small colony of *F. fusca*, kills its queen in single combat and is adopted by the leaderless colony.

In some species no more raids are made after the colony is well established and the black "slaves" gradually die off, leaving an unmixed, self-supporting colony of red ants. The "amazons," however, have become so specialized for combat that they are unable even to feed themselves, much less care for their young or build nests. They, like the knights of old, occupy themselves only in home defense and foreign aggression, the latter being represented by the raids on black ant colonies, which must be continually carried on in order to keep the "working classes" of the colony up to full strength.

In the ants which Wheeler classes as temporary social parasites, as in some of the slave-makers, the parasitism is only evident at the time of founding the colony. In these ants the young queens are

of unusual appearance, either of very small size, peculiarly colored, or furnished with long yellow hairs. After her marriage flight such a young queen enters the nest of some other species of ant, where she seems to completely captivate the alien workers, so that they either allow her to kill their own queen, or themselves eliminate their own "ruler" so that they can devote all their energies to caring for the fascinating stranger and her progeny. This type of social parasite never carries on raids on other colonies, so that when the original alien workers die of old age, a thriving colony of the parasite is left to carry on a self-supporting existence without a trace of its parasitic origin visible.

The most specialized of all the types of social parasitism is that which Wheeler calls permanent or chronic social parasitism. This condition is found not only in several different groups of ants, but also among hornets and bumble-bees, so that it must have arisen several different times among the social Hymenoptera. These permanent social parasites all agree in having no worker caste, but only functional males and females. They never occur in colonies of their own, but are always intruders into the colonies of some other species, where they delude the workers into feeding them and according to their progeny the same treatment which they give their own male and queen larvae. Such parasites lead a rather short and precarious existence, since they are unable to care for their own brood and must perish with the death of the host workers.

Among the ants, at least, these parasites begin their career in much the same way that has already been described for the temporary social parasites. The young queen invades the colony of some other species of ant. Here the alien workers at first receive her with suspicion, but soon come to tolerate and finally to adopt her, eventually assassinating their own queen and devoting all their energies to caring for the multitudinous progeny of the interloper. These progeny are, of course, all functional males and females, so that the entire colony must perish when the alien workers die. In some of these permanent social parasites the males are wingless, and the females are fertilized before they leave the nest, instead of during the usual marriage flight.

In all the cases of permanent social parasitism it is noteworthy that the parasites and their hosts are always very closely related species. This seems to be the same type of phenomenon that is found in the so-called "cannibalistic" mosquito larvae, where a few species in widely divergent groups have become specialized for feeding, not on minute animal and plant organisms, but on other mosquito larvae. Here also the "cannibalistic" larvae always feed on the larvae of closely related species which inhabit the same type of

breeding places. Both of these phenomena seem to result from the modification of a single habit without corresponding modifications in others. The species which have developed the predaceous feeding habit, or the socially parasitic mode of life, have not changed their breeding places, or their nesting habits. So, naturally enough, the species with which they come in closest contact and on which they can most easily prey or become parasitic belong to the same ancestral stock as themselves; a stock which retains both in its original and in its modified form the same breeding or nesting habits which it had developed long ages before food scarcity or laziness impelled some members of the stock to prey on or parasitize other members.

Wheeler also points out that the ants which live as social parasites are always rare. This is not surprising. It is axiomatic that any parasite which inflicts serious injury on its host must necessarily be rarer than the host, else the host species, and with it the parasite, would be exterminated. This is true, not only of the social parasites, but also particularly of the parasitoid insect parasites.

This completes my brief and inadequate survey of the various phenomena in insects which may be classed under the general head of parasitism. By way of conclusion, I would like to devote a few lines to the question of degeneration in parasites. Parasites, both among the insects and in other groups of animals, are often spoken of as degenerate organisms. I presume that those who use this adjective mean that the parasites lack or possess only vestiges of certain organs which are found in free-living organisms. This, of course, can not be denied. But no stigma should attach to them on this account. The same process occurs in the evolution of free-living insects. The footless, almost headless, maggot of many of the higher flies, wallowing in the filth on which it feeds, is as degenerate in this sense as any of the parasites.

And, in principle, the mere loss of organs is no criterion of degeneracy. It has even been said that "all progress must necessarily be attended by degeneration," meaning, I suppose, that adaptation to particular environmental conditions must include the loss of some organs as well as the acquisition or development of others. Internal parasites, protected and isolated by the bodies of their hosts, surrounded by food, often obtaining their oxygen directly from the surrounding medium, have naturally lost such useless organs as those which serve for protection, for finding food, and for obtaining oxygen, and are enabled to concentrate practically all their energies on the two essentials of feeding and reproducing their kind. Such specialization does not deserve the name of degeneration, with its retrogressive implications.

On the other hand, it is true of parasites, as of all other animals, that with such complete specialization for one particular environment there comes also the loss of that youthful adaptability which enables a race to survive changes in external conditions, so that it may be said of organisms, as well as of the cells of the body, that specialization is the first step toward extinction. This is true of all organisms, and when we read such a statement as that of Dr. Wheeler that "the number of forms which during geological times have descended to this 'limbus parasitorum' must be considerable," we must also keep in mind the fact that the parasitic forms represent only a fraction of the multitudes of animals and plants which have perished from the earth without leaving descendants because their specialization for particular environmental conditions was so beautifully exact that it left them helpless, with no choice but extinction, when those environmental conditions were replaced by others.

FIVE FUNDAMENTAL CONCEPTS OF PURE MATHEMATICS

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THE five fundamental concepts which we aim to consider briefly are those of natural number, unknown, postulate, function and group. It is not implied that these are the only fundamental concepts of pure mathematics, but they seem to occupy a very prominent position, if not the most prominent position, among the fertile concepts in the development of this subject. The first two appear already explicitly in the work of an Egyptian, commonly called Ahmes, which is supposed to have been written about 1700 B. C., and was recently republished by the Liverpool University Press with an English translation and commentary by T. E. Peet. The third occupies a prominent position in the mathematics of the ancient Greeks, who used it largely for the purpose of divorcing mathematics and philosophy. The last two were not noted explicitly in their general forms until comparatively recent times, having received special names for the first time towards the close of the seventeenth and the eighteenth century, respectively.

It is probable that most mathematicians would place the concept of natural numbers at the head of the fundamental concepts of our subject. This view was expressed by L. Kronecker in the following words: "God made integers, all else is the work of man," while H. Minkowski said in the preface to his "Diophantische Approximationen," 1907, "Integral numbers are the fountainhead of all mathematics." The arithmetization of mathematics during recent decades exhibits more and more clearly that the natural numbers play a fundamental rôle not only in the early development of our subject but also in the recent efforts to secure greater rigor of treatment. By natural number it is customary to denote the positive integers 1, 2, 3, . . . , but B. Russell includes 0 among such numbers on page 3 of his "Introduction to Mathematical Philosophy," 1919. Historically, 0 does not belong to the category of natural numbers. In fact, 1 was not regarded as a number by Euclid and many of his followers even as late as the seventeenth century, but it is now so regarded by all.

While it may be assumed that few mathematicians would object to the statement that the concept of natural numbers is the most fundamental concept of all mathematics, it is not likely that there would be equal unanimity as regards the one which should occupy

the second position. The unknown as it presents itself in an algebraic equation would doubtless receive much support for this distinction. It also appears in the work of Ahmes to which we referred above with a special name meaning *heap*. It stands, therefore, as a fully developed concept at the beginning of mathematical history, and, as we know nothing of the stages of its development, it and the concept of natural number may be regarded as prehistoric mathematical concepts. The great subject known as *algebra* was developed around this concept, and, as algebra is the most extensive algorithm of science, the concept of unknown stands largely for the formal side of this subject. In particular, mathematical formalism, which enables us to consider millions of special cases at once, was largely inaugurated through the study of the unknown as it presents itself in an equation.

Among the obvious fruits of this study are the theories of algebraic numbers and substitution groups. In particular, the ordinary complex numbers, whose study occupies such a central position in the mathematical developments of the nineteenth century, received their greatest impulse from the formal solution of the cubic equation during the first half of the sixteenth century. It is important to emphasize the fact that this solution was only formal and was not fully understood until a much later date. Mathematics is not the science of solving problems, nor is it the science of avoiding the solution of problems as has been claimed by some. On the contrary, it aims at intellectual penetration by the most general formalism that can be readily interpreted. This interpretation has sometimes been far behind the development of the formalism, as was the case in the development of the theory of ordinary complex numbers in particular.

The history of the unknown furnishes one of the most interesting examples of capitalization of our ignorance. The mathematician often represents a certain type of ignorance by the symbol x and trails it until it involves itself in the form of an algebraic equation of degree n. He then studies this equation as a subject by itself and finds $n-1$ other unknowns involved therein. His equation thus often gives him much more than he put into it and hence it is quite different from an equation in chemical symbols. In other words, the mathematician has made capital of his ignorance by means of the equation, while the chemist has used the equation as a convenient notation to exhibit clearly what he already knew. It is true that the mathematicians were very slow in taking advantage of some of the fruits of the algebraic equation. In particular, the ancient Greeks ignored this fruit entirely, except that some of the later Greeks used irrational numbers to some extent.

They did not use negative numbers as such, although Diophantus came close to their use by employing certain subtracted numbers as separate entities with which one can operate.

The statement that mathematicians capitalized ignorance in using the algebraic equation may deserve further elucidation, since the evidences tend to show that much of the capital which was later derived from this use in the form of an extension of our number concept was not recognized by the mathematicians for a long time. In fact, it might perhaps be said that it was not sought by them but forced itself on them and enriched them immensely. Ordinary complex numbers, which are now extensively used even in applied mathematics, are needed in the solution of many quadratic equations and present themselves in a very practical form in the common formulas used for the solution of the general quadratic equation in one unknown. The ancient Greeks had rules which are equivalent to some of these formulas. They used these rules to find a positive root of many special quadratic equations and hence were on the verge of the wonderful mathematical gold mine represented by the ordinary complex numbers, but they failed to enter this mine. They were not mathematical miners, they were mathematical agriculturists and reaped rich agricultural harvests, as is well known.

For reasons which I fail to understand it is commonly said that the Greeks solved the quadratic equation. This statement appears even in some of our best works of reference, such as Pascal's "Repertorium der höheren Mathematik," volume 1 (1910), page 250. In a recent American history of mathematics it is even stated "that the general quadratic equation as we know it to-day was thus fully mastered by the Greek mathematicians." It seems to me that if all that the Greeks knew about the quadratic equation were known by one student, but if this student had no further knowledge about this subject, he would fail to make a passing grade on an ordinary set of examination questions now given to freshman students in our universities. It may, of course, be said that the expression "the Greeks solved the quadratic equation" need not imply more than that they had rules which were equivalent to modern general formulas for this solution, but the quotation noted above shows that even a mathematical historian was recently led to infer much more therefrom and hence its inappropriateness seems to be established.

It was noted above that the ancient Greeks did very little towards the extension of the number concept, although such an extension appears very natural from the stage of advancement which they had attained. On the other hand, they secured immortal glory by the explicit introduction of the third and middle of

the fundamental concepts noted in the opening sentence. The concept of postulate and postulate system is primarily an acknowledgment of ignorance, just as the use of a special symbol for the unknown, but there is also a very marked difference between these two concepts and their effects upon the further development of our subject. The symbol for the unknown used both as an operator and as an operand led to intricacies whose disentanglement gave rise to a very unexpected broadening of the mathematical horizon, while the system of postulates limited the extent of this horizon but led to a much deeper insight into the contents of the field thus limited. The concept of the unknown is a concept of extension, while that of a system of postulates is a concept of intension.

The "Elements" of Euclid furnish the best known example of the Greek use of a postulate system. They constitute also one of the best known examples of the divorce of mathematics and philosophy, a divorce which was not always maintained in later years. Even some of the later Greeks, for instance, Nicomachus, tried to effect a reconciliation. It is, however, an interesting scientific fact that a work in which this divorce is so marked became the most noted text-book ever written and is said to have passed through more editions than any other book besides the Bible. The so-called Archimedean postulate, which assumes that if there is a difference between two quantities this difference when taken a sufficiently large number of times becomes larger than any given quantity, also enabled the Greeks to make much progress which would have been impossible if they had always admitted the existence of the actually infinitely small quantities. This postulate is implicitly contained in Euclid's "Elements" and was used earlier by Aristotle and possibly by Eudoxus, although the angle between the tangent of a circle and the circle constitutes a magnitude which does not obey it.

From the Archimedean postulate we see that the idea of postulates, introduced by the Greeks, served not only to bring about a practical divorce between mathematics and philosophy but also a restriction of view so as to make advances in this restricted area more effective. The concept of postulate is so widely different from the other four noted in the opening sentence as to make a relative valuation very difficult if not impossible. Those who call mathematics a Greek science would naturally give this concept a relatively high position among the fundamental concepts of our subject. Historically, it is a concept of very great significance since it served to inspire confidence and to secure clarity of view, even if mathematicians for a long period lost sight of the fact that other systems of postulates are possible, and that there is no essential difference between axioms and postulates of mathematics.

The three concepts whose salient features have been outlined above usually receive considerable attention in the courses in elementary mathematics, while the remaining two belong primarily to advanced mathematics. Both of these extend, however, also to the elements of our subject. In fact, these particular five concepts have been selected with a view to their very wide range of mathematical influence. The fact that the concept of functions extends into the elements of our subject is illustrated by the appearance of a special name for a trigonometric function in the work of Ahmes. We, therefore, find at the beginning of mathematical history a name for what is now known as a transcendental function, but the first definition of the general concept of function seems to be due to John Bernoulli I (1718). There is, therefore, a period of more than three thousand years between the time when a name for a special function was first used and when a general definition of the concept of function was first made known.

It seems reasonable to regard the general concept of function as an outgrowth of the concept of unknown. It was noted above that the unknown frequently presents itself entangled in the form of an algebraic equation. Other expressions involving the unknown appeared early in the development of our subject. It was natural to consider these expressions as symbols by themselves and to allow the unknown, or unknowns, involved therein to assume various values. The corresponding values assumed by or assigned to these expressions when the unknowns are regarded as variables are also variables and are *functions* thereof. Since related variables present themselves so commonly in nature it is evident that a training in functional thinking is of great usefulness to those who seek an intellectual penetration into their surroundings. This explains the growing emphasis on the concept of functions in some of our elementary courses of mathematics as well as the appearance of so many works devoted explicitly to the subject of function theory.

Since the last one of the five fundamental concepts under consideration is probably the least generally known and some readers may be inclined to think that it should not be included among the five most fundamental concepts of pure mathematics it may be noted here that in the introduction to his book entitled "Einleitung in die Theorie der Invarianten linearer Transformationen auf Grund der Vektorenrechnung," 1923, E. Study remarks that mathematics concerns itself with a system of laws which are mostly of a group theoretic kind. It may also be noted that in one of his last addresses H. Poincaré said that "the theory of groups is, so to say, entire mathematics divested of its matter and reduced to a pure form" ("Acta Mathematica," Volume 38 (1921), page 145). The

American reader may be interested in the fact that a recent French writer said "the theory of finite groups has become a theory which is largely American" (A. Buhl, "L'Enseignement Mathématique," Volume 22 (1922), page 216).

One of the most important mathematical groups is composed of the positive rational numbers as regards the operation of multiplication. This group appears in the work of Ahmes with the special name of number, and it constituted the totality of the number system for about two thousand years thereafter when, as noted above, some of the Greeks during the period of decadence calculated with irrational square roots as if these roots were numbers, without considering their geometric origin. It is not likely that the ancient Egyptian mathematicians had a clear notion of this number group or of the trigonometric function to which they gave a special name. The founding of the theory of groups as well as the founding of the theory of functions lay more than three thousand years ahead of their times. The fundamental nature of the concepts of group and function is, however, partly exhibited by the fact that special cases of these concepts presented themselves so early and continued to present themselves in the later developments.

Even those who would not agree that the five concepts which are under consideration constitute the best selection possible as regards fruitfulness in the development of pure mathematics would doubtless agree that they do constitute a very significant set of concepts whose dominating influence entitles them to the respect which we render to the mighty forces of this world. In view of their great simplicity one might at first not suspect that they are the source of so much that appears complicated and profound. They have not only led to new domains of thought, but they have also tended to exhibit order where there seemed to be chaos, and comparative simplicity where otherwise there seemed to be only an endless multitude of special cases. The formalism to which they have given rise constitutes an intellectual elegance which is not superficial and fruitless but penetrating and enriching, since it gives us an insight into how nature works without losing ourselves in a maze of apparently disconnected facts. Fortunately, it always leads to new difficulties and the exposure of these has ever been the source of scientific progress.

IS THERE A NATURAL LAW OF INEQUALITY?

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THE doctrine of equality is derived chiefly from Rousseau, Locke, Montesquieu and other social and political philosophers of the latter part of the eighteenth century, although it was implied long before in the Roman juridical maxim, "omnes homines natura aequales sunt." It was formally asserted in the French Declaration of the Rights of Man, in 1789, and had previously been expressed on this side of the Atlantic in the Virginia Declaration of Rights, June 15, 1756, and in the Declaration of Independence in the famous proposition, "All men are created equal."

From the foundation of this government until recently, except in the south for a short period before the Civil War, this doctrine has been almost generally proclaimed as the fundamental idea and logical basis of democracy. The southern states attempted to found a government upon the opposite principle. After the organization of the Confederate States of America, and on his election to the vice-presidency thereof, Alexander H. Stephens, in an address to the citizens of Atlanta, said that the foundations of the new government were laid "upon the great truth that the negro is not equal to the white man, that slavery, subordination to the superior race, is his natural and normal condition." "This, our new government," he continued, "is the first in the history of the world based upon this great physical, philosophical and moral truth." The outcome of the war, however, discredited this "great truth," and many doubtless supposed that we should hear no more of it. But within the last few years, and particularly since the Great War, far from being admitted as a self-evident truth, the proposition that all men are created equal has been vehemently denied, and the old doctrine of inequality has again been brought forward with claims of a natural sanction and an ethnological and scientific foundation.

A recent critic (Joseph Collins), for instance, writing of Georges Duhamel, the French poet and pacifist who worked in French hospitals during the late war, says:

> He saw man in his agony give the lie to the most misleading of all statements: that man is born equal. For neither in living nor in dying is there equality. Men are equal, we trust, before God, and they are alleged to be equal before the law, but after that, equality of man does not exist.

After this deliverance we are not greatly surprised to find the same critic giving utterance to this further contribution to political philosophy: "If any *ex cathedra* statement is justifiable it would seem to be this—the World War flowed more or less directly from the revolutionary movement which began with the dissemination of the doctrine of the French philosophers, especially Rousseau, toward the end of the eighteenth century." Rousseau, then, with his specious doctrine of equality, not Bismarck, the Hohenzollerns and Prussian (and other) militarists, was responsible for the late war. It would be gratifying to have a question thus settled about which there has been much difference of opinion—if only it could be settled *ex cathedra*.

Again, from an article by President George B. Cutten, of Colgate University, published in the New York *Times*, July 1, 1923, and entitled, "Nature's inexorable law—inequality," we learn once more that the statement in the Declaration of Independence that "all men are created equal" is "untrue to facts." "The phrase sounds well," he says, "but when we attempt to find anything in nature which accords with it we are doomed to disappointment, for nature's inexorable law is inequality."

This article, by the way, is apparently only an echo of the doctrince proclaimed by Lothrop Stoddard in his book, "The Revolt against Civilization." The second chapter of that book is entitled "The iron law of inequality." It begins as follows:

> The idea of natural equality is one of the most pernicious delusions that has ever afflicted mankind. It is a figment of the imagination. Nature knows no equality. The most cursory examination of natural phenomena reveals the presence of a Law of Inequality as universal and inflexible as the Law of Gravitation.

Thus we learn that, owing to a law of inequality in nature, the famous statement of our Declaration of Independence that "all men are created equal" is palpably absurd.

Well, if it is it is not because of any natural law of inequality, for there is no such law, as we shall now see.

On what ground is it asserted that there is a natural and iron law of inequality? It is merely the ground of the indisputable fact of infinite variety in nature. No two things in nature are exactly alike. This holds, of course, with regard to men. No one is likely to dispute the declaration that of the billion and a half or more people in the world it would be impossible to find any two of them that are in all respects exactly alike. Not even "identical twins" are identical. When nature makes a man she breaks the molds. Now, is this admitted fact, or so-called law, of variation equivalent

to a law of inequality? Not unless variation and inequality are equivalent terms, which plainly they are not. "No two individuals are ever precisely alike," says Stoddard. "The leaves of the trees, the blades of grass, the flowers of the field, no two of these are either alike or equal," echoes President Cutten. But why "alike or equal"? Are these terms interchangeable? Certainly not. Things are alike or unlike as an objective fact of nature. They are equal or unequal only as judged by man from a subjective standard of comparison. Man, then, not nature, determines equality or inequality. His standards vary; so also will his judgments as to the things compared. The same things, though visibly unlike, may be adjudged equal at one time, unequal at another. A shift of standards may reverse his judgment. A pansy and a peony differ in size, shape, color and fragrance; but whether they are equal or not, say for decorative purposes, depends upon the design and taste of the decorator. A percheron and a Kentucky thoroughbred are obviously unlike; but to say that they are equal or unequal is meaningless unless the standard or viewpoint of comparison is known. One is superior for draft purposes, the other for racing. They may indeed be equal from the standpoint of height or beauty or value. Is it not clear, then, that while variation or unlikeness is undoubtedly found in nature, inequality or equality exists there only as man interprets the unlikeness, that is, only in the mind of man as the expression of a judgment that may be true or false? The law of variation, then, is not a law of inequality.

Lest it be said that we are stating a distinction without a real and significant difference, let us pursue the subject a step further. A natural law admits no exception. An exception proves a rule, but it destroys a law. Are there, then, no exceptions to the so-called natural law of inequality? Is it true that no two things in nature—leaves, blades of grass, flowers, men—are equal in any respect? Obviously, leaves may be naturally equal in length, grass in color, flowers in beauty and men in size or weight. Such obvious exceptions to natural inequality are sufficient to dispose of this so-called "iron law," and to show that conclusions based upon it or inferences drawn from it are invalid. "There is in fact," says Stoddard, "no such word as equality in nature's lexicon." It is equally true that no such word as inequality is to be found there.

What the opponents of the doctrine of equality have mistaken, then, for a natural law of inequality is merely the fact of infinite variety in nature, plainly recognized by students of nature for more than a hundred years. It is a beneficent fact, too, for without it there could have been no evolution through natural selection; there would have been nothing from which to select. But it is rather a

fact than a law, and the fact of variation, as we have seen, has nothing to do with equality or inequality unless or until man appears with some standard of comparison, and this standard with respect to men may not have anything particular to do with social policy or social progress. There is, therefore, we repeat, no such thing as a natural law of inequality.

But, in passing, suppose there were such a law, what of it? Is a natural law an insuperable barrier to progress? Quite the contrary, it is a condition to progress. If there were no natural law of gravitation, how could we build securely? If there were no natural laws of heredity, how could we hope to develop a science and an art of eugenics? Suppose, then, that men were made unequal in certain respects, it does not follow that they must or should always remain so. Certainly social progress must be in the direction of the removal of artificial inequalities. Why not also of certain natural differences? This, however, is a digression.

Artificial inequalities, it will be asserted, are the results of natural individual differences, particularly differences in mental capacity. Here we reach the crux of the matter under discussion. What the advocates of the doctrine of inequality are chiefly concerned with are inequalities in native intelligence. They wish to show, not merely the undisputed fact that such differences exist, but that they are merely manifestations of the divine order of things, natural and ineradicable, and that we should proceed accordingly in government and in education. Here again their logic is at fault. No two things in nature are alike, they say, therefore no two men are equal in intelligence. But it is not true that no two men are equal in intelligence or mental capacity. If our standardized tests of intelligence be applied to a large number of men, it will be found that some of them, indeed many of them, will have the same intelligence quotient. This means, at least, that they are so nearly equal in intelligence that the difference can not be determined by any tests thus far devised.

If, in order to escape the inevitable negative conclusion implied by this illustration with respect to the existence of a natural law of inequality, it be declared that what is meant is that men in masses, that is, in classes and races, are unequal in intelligence, then we have a question of fact, not a corollary of a law of nature, that can be determined only upon the basis of the pertinent scientific evidence. Now, what evidence have we to support the doctrine of inequality even of races? The careful student must admit that it is very little.

The best witnesses on this point are the ethnologists and anthropologists. Let us note what some of them have to say in regard to it.

Professor Franz Boas, certainly one of the foremost anthropologists of this country, declares that the belief in racial inequality is

> based essentially on the assumption that higher achievement is necessarily associated with higher mental faculty, and that therefore the features of those races that in our judgment have accomplished most are characteristic of mental superiority. We subjected these assumptions to a critical study, and discovered little evidence to support them. So many other causes were found to influence the progress of civilization, accelerating or retarding it, and similar processes were active in so many different races, that, on the whole, hereditary traits, more particularly hereditary higher gifts, were at best a possible, but not a necessary, element determining the degree of advancement of a race.[1]

In his opinion we are not able at the present time to form a just valuation of the hereditary mental powers of different races.[2] This is practically the opinion of the other leading authorities in this field. "No proof has been forthcoming of the inferiority of the other racial stocks to the white," says Goldenweiser.[3] "Any successful attempt to evaluate the innate mental differences of peoples," says Holmes,[4] "would involve a thorough investigation by the best modern methods and on an extensive scale. As no such investigation has ever been made we have no very adequate basis for asserting which of the civilized peoples of the earth are the most highly gifted with inherited qualities." Wissler, though he believes there are indirect evidences of racial inequality, declares that "the import of our comparative studies of culture history is that no one racial strain, like the Nordics, for example, can lay claim to more than an incidental contribution to culture as a whole."[5]

Finally, Kroeber, after a critical examination of conclusions drawn from the army tests, thus expresses his view:

> As a matter of fact, the bodily differences between races would appear to render it in the highest degree likely that corresponding congenital mental differences do exist. These differences might not be profound, compared with the sum total of common human faculties, much as the physical variations of mankind fall within the limits of a single species. Yet they would preclude identity. As for the vexed question of superiority, lack of identity would involve at least some degree of greater power in certain respects in some races. These preeminences might be rather evenly distributed, so that no one race would notably excel the others in the sum total or average of its capacities; or they might show a tendency to cluster on one rather than on another race. In either event, however, the fact of race difference, qualitative if not quantitative, would remain.

[1] "The Mind of Primitive Man," New York, 1921, p. 244.
[2] *Op. cit.*, p. 122.
[3] "Early Civilization," New York, 1921, p. 6.
[4] "Studies in Evolution and Eugenics," New York, 1923, p. 92.
[5] "Man and Culture," New York, 1923.

> But it is one thing to admit this theoretical probability and then stop through ignorance of what the differences are, and another to construe the admission as justification of mental attitudes which may be well founded emotionally but are in considerable measure unfounded objectively.
>
> In short, it is a difficult task to establish any race as either superior or inferior to another, but relatively easy to prove that we entertain a strong prejudice in favor of our own racial superiority.[6]

We quote these ethnologists merely to show the status of the question of racial equality or inequality. We do not advocate the one or the other. We are merely concerned with showing that inequality in races, classes or individuals is not to be inferred from an iron law of nature, but is only to be determined upon the basis of scientific evidence, and that evidence is as yet somewhat meager.

We have shown that there is no iron law of inequality in nature. But in so doing we have shown also that neither is there a natural law of equality. Nature knows no more of the one than of the other. Must we not admit, then, that the declaration that "all men are created equal" is an altogether unfounded assertion, a mere glittering generality or worse?

Before we dismiss the proposition as the "most misleading of all statements" let us see whether after all it does not embody something like a self-evident truth. It would appear to be self-evident that all men are created equal in helplessness, in ignorance and in innocence. Perhaps there is some other respect in which the natural equality of men was thought to be self-evident by the fathers of this republic. What did they really mean by the proposition? What was their subjective standard of comparison?

Well, they could not possibly have meant what the advocates of inequality imply they did. Variety in nature—natural differences in plants, animals and men—is a fact so obvious that it could hardly escape the observation of a child. Certainly it was not overlooked by the philosophers of the eighteenth century. Rousseau himself recognized the existence of what he called natural or physical inequalities, such as "differences of age, health, bodily strength and intellectual or spiritual qualities," and carefully distinguished them from "the different privileges which some enjoy, to the prejudice of others, as being richer, more honored, more powerful than they, or by making themselves obeyed by others." Such inequalities, he thought, are dependent upon "a sort of convention and are established, or at least authorized, by the consent of mankind." It was only the latter that he wished to remove. Surely nobody in his senses ever meant to say that men are equal in all respects, that is, equal by every standard of comparison. We pay little homage to

[6] "Anthropology," New York, 1924, p. 84–5.

the intelligence of the framers of the Declaration of Independence, then, and give little evidence of our own by asserting or implying that they ignored or meant to deny the fact of variation. They were as clearly aware as President Cutten, that, from the corresponding standards, "men are unequal physically, unequal mentally, unequal socially," though they would not have assigned the entire responsibility for that fact to a law of nature. Some of these inequalities are plainly due to inequitable and unjust social conditions. What, then, did they mean?

"Most people think," says President Cutten, "that the proud, slave-holding, Indian-hating aristocrats who were responsible for the Declaration of Independence meant that all human beings were equal. Of course, they didn't. They meant that certain property holders on this side of the Atlantic were equal to certain property holders on the other side—that was all. Negroes and Indians and poor whites and women were not equal to Virginia planters and political leaders—not by a jugful." This, however, is a libel on the men who framed the Declaration of Independence. They knew and admitted that slavery was an evil. But it was in existence, it was entrenched behind constitutional guaranties, they had no hope of its immediate elimination. They were confronted by a condition, not a theory. They regarded slavery as wrong, and looked hopefully to its gradual and final extinction. This was proved to the hilt by Abraham Lincoln in his Cooper Union speech, February 27, 1860. When they said, then, that "all men are created equal," they meant exactly what they said. They meant that from a certain viewpoint, the viewpoint they had in mind, men should be regarded as equal. To assert the contrary is to belittle them to the stature of cheap politicians formulating a party platform merely to catch votes. But what was that viewpoint?

The founders of this republic were not interested in biological and psychological comparisons. They were concerned with a form of government and a doctrine of rights. The Virginia Declaration and the French Declaration were both declarations of rights. The French Declaration reads, "All men are born free and equal; not one of them has more right than another to make use of his natural or acquired faculties; this right, common to all," etc. The Virginia Declaration declares, "All men are by nature equally free, and have inherent rights," etc. So the framers of the Declaration of Independence, equally concerned with human rights, meant to assert that all men, from the viewpoint of just human relationships, are equal in their rights to participate in their own government and to enjoy life, liberty and the pursuit of happiness; that these rights are inalienable; that one man, as much as another, is entitled to develop

his personality without the selfish interference of those who would use him as a means to their own ends. They meant to assert that self-government is the only rightful basis of any government. Lincoln suggested one aspect of the idea when, in speaking of a black slave woman, he said, "In some respects, she certainly is not my equal; but in her natural right to eat the bread she earns with her own hands, without asking leave of any one else, she is my equal and the equal of all others." This is what the Declaration of Independence asserts, and this is what the philosophers of the eighteenth century had in mind. They were merely stating the fundamental principle of democracy as against the selfish, brutal and soul-destroying rule of a hereditary dominant class. And this principle is a vital truth and must be maintained against Nordic propaganda and against pseudo-scientific declarations concerning natural racial or class inequality. All honor, then, to Jefferson, as Lincoln remarked, all honor "to a man who, in the concrete presence of a struggle for national independence by a single people, had the coolness, forecast and capacity to introduce into a merely revolutionary document an abstract truth, applicable to all men and all times, and so to embalm it there that to-day and in all coming days it shall be a rebuke and a stumbling block to the harbingers of reappearing tyranny and oppression."

Why, then, this modern and apparently concerted effort to make the Declaration of Independence appear ridiculous by insisting upon a literal and general interpretation of the phrase, "all men are created equal," and by attempting to prove the fathers of our republic ignorant or insincere because they approved the sentiment?

When we find it proclaimed that the doctrine of equality is absurd because men are so obviously different, that by a great and recent discovery in biology it is revealed that no two plants or animals, much less men, are exactly identical, that there is an iron law of inequality, and that our Declaration is an outworn and delusive document, we suspect that there is behind it some other motive than the disinterested desire to set the world right on a question of natural history. There is, we believe, an ulterior motive, and that motive is to discredit democracy. The denial of the doctrine of equality may be taken as an infallible sign of political reaction.

President Cutten, for instance, makes his discussion of nature's so-called inexorable law of inequality the prelude of an attempt to prove, first, "that socialism is psychologically impossible," mental inequality being the chief barrier and the greatest argument against it, and that "the present organization of labor unions is impossible

as a permanent scheme." Secondly, and more important, that democracy, as we are accustomed to conceive it, is also impossible. "Our nation," he says, "is ruled by a few men now just as it always will be. Only a small proportion of people in our country, or any country," he says, "have sufficient mental ability to govern themselves." They must, therefore, be governed by others. He would improve upon Lincoln's famous Gettysburg speech by defining democracy as a "government of the people, for the people, by all those of the people mentally able and morally capable of doing so"—that is by *us*. He apparently fails to see that this is oligarchy, an aristocracy, not democracy. He accepts, too, the fallacious statement of Babson that "statistics teach us that practically all we have to-day in the form of factories, stores, railroads, steamships, newspapers and books is due to the enterprise of only two per cent. of the population," and thinks the fact that the major part of the nation's wealth is owned by less than two per cent. of the population is about as it should be, since this two per cent. constitutes almost half of the mentally superior people.

Stoddard, also, posits his "iron law of inequality" in order to establish a new political philosophy, what he calls Neo-Aristocracy. This is that the great mass of the people, fully 70 per cent., he says, are incapable of self-government and must be governed by their superiors. "Nature has decreed them uncivilizable." They perceive somehow, however, and in spite of their mental incompetence that progress is not for them, that they are getting the worst of it. "Let us, then, understand once for all," he says, "that we have among us a rebel army—the vast host of unadaptable, the incapable, the envious, the discontented, filled with instinctive hatred of civilization and progress, and ready on the instant to rise in revolt" —in revolt against civilization, mind you, and not against the ineptitudes, injustices and iniquities of civilization. "Here are foes," he says, "that need watching. Let us watch them." According to the figures of the army tests, which he accepts uncritically, 70 per cent. of our enlisted men in the Great War are among these foes. They belonged to that great army of "the unadaptable, the incapable and envious." Still they fought, or were ready to fight, the great war for democracy, and fifty thousand of them gave their lives to that great cause. Who provoked that war or so grossly mismanaged the affairs of government as to make it inevitable? Who led the world into the conditions that made it a slaughter house, resulting in the destruction of ten millions of men and three hundred and fifty billions of property? Certainly not this class, but their so-called "mental superiors."

If anybody needs watching, then, is it not rather those who would recover the remnants of the doctrine of inequality from the battlefields of Europe and of America where we had thought it was shattered forever so far as this country is concerned, and piece it together, refurbish it and parade it as a sacred political doctrine sanctioned by an iron law of nature; is it not rather those who because of the way it happens to have been expressed a hundred and fifty years ago pour ridicule upon the doctrine of equality and deny the equal and inalienable right of men to life, liberty and the pursuit of happiness. "As if it harm'd me," as Walt Whitman said, "giving others the same chances and rights as myself—as if it were not indispensable to my own rights that others possess the same."

PHILOSOPHY IN MEDICINE

By Professor HORST OERTEL

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IT is a common and prevalent opinion of the present day that philosophy—that is, the general knowledge and ideas of the nature and relation of things—and medicine have nothing to do with each other. Any attempt to include the study of philosophy as a preliminary requirement for the study of medicine would create laughter, a storm of protests, and, if it came to a vote at all, be summarily rejected with ridicule by many of our modern medical faculties. Long speeches would be made around faculty tables that we are to educate practitioners, not scientists, that the requirements of preliminary training, even in the fundamental sciences, should be reduced to the absolutely necessary minimum, and that we must remain "practical." Few of those arguing in this manner would appreciate that they themselves are already preaching a system of philosophy—naïve, crude and superficial though it is—which, nevertheless, embodies a general conception and belief of life and order of things.

And thus it is; we may all ridicule philosophy, smile at the involved thoughts and unpractical ideas of the "school" philosopher which we reject, because we do not understand them, or because their contents do not come within our own field of vision, but, after all, we are all moved by the same questions: What is life? What is our position and mission in it? Whence come we? Where are we going? What are our relations to other beings, and to the things around us? In short, what is the secret of this world? These ideas come to us at one time or another, whether we wish to entertain them or not. And in spite of our efforts to sidestep them or to abandon them as useless, they force us with elemental strength to some sort of answer. Thus it happens that every human being, savage, business man, even lawyer and doctor, adopts a position in regard to these questions. Our whole existence is shaped by this position. Inevitably the human mind is driven to it. The philosophical attitude of the individual may not be original with him; frequently it is not; but nevertheless it exists in him and controls his views and actions. One may venture to say that the force of philosophical conceptions is so strong that they, more than any other, determine man's actions and thus the history of the world. This is equally true of the grossest materialistic and selfish ideas as

of the highest spiritual altruistic motives of which the human mind has ever been capable. Thus, Hegel, properly and profoundly, defined the history of philosophy as "the history of the world-moving ideas."

Thus also the sciences are children of philosophy or of that impulse which, for one or the other reason, forces the human mind to investigate the nature and connection of things. True enough, the immediate impetus of progress was often a very practical or protective one, but the result became at once the basis for generalization, and when the desired result was defeated, it became the source of speculation. When the king of Siam was told at one time by the Dutch ambassador that in his country, Holland, water would solidify at certain times of the year so that it was possible to walk on it, the oriental monarch refused to believe it on the ground that the very idea of water necessitated a fluid quality—a perfect example of philosophical empiricism.

Out of such at first naïve and unconnected conceptions grew, with experience, scientific thought and method of reasoning. Conflict with dogma and authority stimulated their advance to greater clarity of fundamental principles and correctness and simplicity in putting questions. Thus arose our present scientific method of investigation. This evolution was a long, laborious, often dangerous one. It proceeded unevenly in the different branches of science, through innumerable personal sacrifices, and it is still far behind in many. The biological sciences, upon which the practice of medicine is based, arrived latest at this method, and are, therefore, still least developed in this respect. Of these again, pathology, the science of disease and the immediate support of medicine, still wears a child's habit as a science. Strange as it may seem, it is still clothed in the garb of the oldest scholastic period of philosophical reasoning. For it has not yet learned to distinguish fully between what is scientifically established and what is assumed. That is the greatest fault of the medicine of to-day. Here I enter upon a plea for the necessity of a philosophical sharpened mind, in order to intelligently follow, appreciate and command the contents of modern medicine. Let me explain!

All human reasoning has two paths of approach: Rationalism and empiricism. The first endeavors to construct things and occurrences out of the mind alone, the second out of experience. The first goes back in modern philosophy to Descartes, the second to John Locke and David Hume. These were combined by Kant into a conception of nature as nothing else but "a system of phenomena which is ordered by the lawful function of our intelligence," and which, not through intellect but "will," leads to higher understand-

ing and moral concepts of the world.* In other words, observations and experience through wilful thought furnish us scientific knowledge and interpretation of the world. Out of these two mental functions arises understanding by causal connection of natural phenomena. This is at first of course quite incomplete and therefore full of exceptions. It is perhaps best typified by popular medicine, which abounds with exceptions which the ordinary person disregards.[1] Thus, if you expose yourself to a draft, you catch cold, but not in every instance. If you have a cold you have fever, but not always. If you take a certain drug, this or that effect will follow, but not always, and sometimes something quite different. In a large number of individuals, any desire to establish a further causal connection never arises. They are satisfied with the old "no rule without exception," or "the exception próves the rule."

Originally, even the deeper philosophical insight, as exemplified by Aristotle, recognized exceptions in natural occurrences, which had to be explained through uncontrollable properties of matter or through a natural lawlessness of action. But gradually causal connection was given a stricter form and requirement. At present it is the duty of all sciences to establish causal relations which proceed with mathematical precision according to never-changing rules of cause and sequence. No physical consequence, therefore, without physical antecedence.

So far, only physics has carried this principle to strict general application, and the laws of mechanics may be regarded as the typical example of natural lawfulness. Descartes insisted upon this for the external world, Hobbes and Spinoza insisted upon it, long ago, as a necessity also for the internal, psychic world. How near are we to it in the biological sciences, more particularly in the field of disease?

We must first make clear to ourselves the meaning of causal connection! The popular belief is that anything, which is immediately followed by a phenomenon in a large number of instances, is its cause. That, however, is entirely unsatisfactory, or, at least, insufficient to establish cause. For the relations of the sequence to the accidence may also be casual, indirect and circumstantial. For this reason, Roux, the founder of evolutionary mechanics, insists that every causal knowledge of a phenomenon must include the complete connected chain of all events which are responsible for it, and, I

* Nothing greater has ever been said in this connection than Kant's phrase: "The starry heavens above me, the Moral Law within me." (Kritik der praktischen Vernunft.)

[1] I take this example from Paulsen's well-known "Introduction to Philosophy."

should add, *in their proper position*, not only one or several, remote or immediate, links. When, for example, we speak of bacteria as *causes* of disease, we are, strictly speaking, not correct. For, while bacteria may be etiologically concerned, they do not give us any understanding of the part they play in infection or of the mechanical connection and nature of the subsequent disease. Thus, the finding of microorganisms gives us no information about the anatomical selection, the mode or origin, the manner of development and of the specific expressions of the anatomical changes which furnish the objective basis of diseases. Consequently, there have been introduced by obliging bacteriologists and pathologists, in order to rapidly hitch their sciences to clinical medicine, all sorts of indefinite, largely hypothetical conceptions, such as "virulence," "attenuated forms," "variability," "resistance," "strains" (which are distinguished by equally uncertain reactions), "individual susceptibility," "carriers." All these cover up deficient knowledge of causal relations, are, at the best, heuristic. The calamity, however, is that these words are construed by some as scientifically established connections of circumstances which may be regarded as finished entities, and thus may be drawn upon to *explain* natural phenomena (to this I shall refer later).

A surgeon told me once that bacteriology was unsatisfactory and worthless to him, because no matter whether he sent a specimen of pus from any part of the body and from quite different diseases or a swab from any ulcer or from a phlegmon or from the throat, or, finally, blood for culture, the report would be nine times out of ten a kind of streptococcus or contamination. He was quite right, in a sense, but he lacked that penetration which should have told him that bacteria are not *the* causes of diseases, but only one of the factors which must be considered in the construction of the causes, and I quite agree that the ordinary routine of bacteriological examination as applied in clinical medicine is a statistical entertainment which gives us not the slightest information as to their rôle in the origin and subsequent development of the disease. Such men are quite at a loss to understand the finding of even pathogenic bacteria in healthy subjects. But even accepting bacteria as a factor which enters into the cause, we possess no exact knowledge of how and how far they enter. We are consequently perfectly unable to define *their exact position* in the causative, nosological complex, simply because we have not the slightest knowledge of the mechanism of the relation between bacteria and body cells. The introduction of such hypothetical conceptions as toxin, endotoxin, esotoxin, do not get us much further, because their existence, molecular constitution and interrelation with the organ-

ism's cells are unknown, and only based on an unfortunately only too variable symptomatic experience. In every instance, causal connection, and that is really the crux of the whole matter, *must establish the connecting bridge between cause and sequence.* In pathology, we possess only one great, although necessarily incomplete, attempt in this direction; that is, the cellular pathology of Virchow, for Virchow substituted for hazy ideas of life and its disturbances mechanical cell acts in response to definite stimuli. This is perhaps best illustrated by his ideas of inflammation. Before him existed only very indefinite views on the nature of inflammation, based either on subjective symptoms or on symptomatic vascular changes or on certain products of inflammation (exudate) or, finally, on injury to nerves. Virchow wiped all these away, for he saw clearly that any explanation or definition must give an account of the mechanism of the lesion. Thus, he boldly placed inflammatory action into the cells, and in his famous article on "Parenchymatous inflammation," traced, as well as he could at the time, the whole causal connection of the lesion, from the stimulus to its end changes, in the cells of the parenchyma. It was a grand attempt at a mechanical explanation. His work, therefore, although superseded in many respects by the discovery of new facts, nevertheless remains as the first monumental effort in pathology to push the mechanical causal connection of pathological phenomena as far as it will go. Thus Virchow broke with that sort of pathological investigation which is willing to rest its mind, as Kant puts it, "upon the bolster of unknown dark qualities." Throughout the whole domain of pathology, Virchow endeavored to introduce mechanistic explanations and, more than any one before or after him, he was instrumental in relegating vital forces and other transcendent powers in the explanation of normal or abnormal processes of life to the background.

It was natural, however, that Virchow, at his time, could not entirely succeed in this task, and he himself was obliged to retain certain *a priori* or transcendental conceptions, where the pure mechanistic explanation failed. Thus, the cell as a "vital unit" endowed with "vital activity" is "passive" in irritation, "active" in reaction, "adapts" itself to "injury" or "resists" it. It has attributes of "repair," "recovery" and "healing" and performs "selective acts." Such and similar transcendental[2] ideas persisted through the reformation of cellular pathology. Thus also Virchow was unable to overcome the idea of transcendent[2] purposes, or the

[2] I use the term *transcendental* in this connection in the Kantian sense as applying to *a priori*, categorical ideas which are necessary to experience, as compared to *transcendent* which applies to what is beyond experience. Identification of these has led to much confusion in pathology.

teleological explanation of natural phenomena which is so often intimately associated with and confused with these *a priori* or transcendental ideas. With the continuation of these ideas, not in sense of convenient categories or as *names* for as yet unexplored or not understood natural phenomena or even as heuristic principles, but as real powers which were coupled with teleological qualifications, the whole of scientific pathology broke right in the middle. Take all the bacteriological, and especially immunological, so-called explanations. What are they? Expression of causal relations or causal explanations? Not at all! Entirely metaphysical ideas! The definitions of "immunity" itself, "resistance," "defense," "purpose," "effort," "agglutinins," "precipitans," 'lysins," "antibodies," "complement," "opsonins," and so on, permeate in the shape of real entities, like a pre-Virchowian nightmare, the whole scientific texture of the infectious diseases. Now it might be urged, once more, that these are simply names or heuristic principles which are employed to cover defects, and as that, they would demand a certain temporary standing. But actually that is not the case, for they are used to *explain* other unknown natural phenomena. Thus, for example, "inflammation" and "immunity" are given a "purpose" of "defense action." Can any one think of anything less scientific and more confused and muddling in reasoning? For what does it mean? If it means anything at all, inflammation and immunity are elevated to the position of independent entities which perform something which is entrusted to them by an unknown power outside of them, in order to protect, defend or heal the individual. Thus, also, chemiotaxis and phagocytosis are regarded as specific cell actions for the "purpose" of assisting the individual in dangerous invasions. In other words, something is read into natural phenomena which has no relation to causal relations or connections. What is worse, however, is that these purely personally assumed metaphysical attributes are now employed—it is really terrible to acknowledge it in the twentieth century—to *explain* natural phenomena. Thus, we read that a "toxin stimulates to the formation of an antibody," and in one modern text-book on pathology, I find "inflammation" compared to the activities of a fire-brigade! Consider what all this means. An unknown assumed quality is employed to furnish us with scientific understanding of other unknown qualities, that is, one unknown explains or is intended to convey to our understanding another unknown, like Baron Münchhausen, who, having got stuck in a swamp, lifted himself by his own hair out of it. And who can help being reminded here of the old one-sided rationalism of the earliest scholastic period which saw in universal ideas realities of independent existence.

(The scholastic period passed, as well known, through three stages, the first and most brilliant assumed the reality of ideas, that is, of universals, *before* things. It is expressed in the phrase *"Universalia sunt realia"* or, *"ante rem."* The second modified this to *"Universalia sunt in re,"* that is, they *lie* in *things*. The third, finally, which inaugurates the disintegration of scholasticism, assumed only *"Universalia sunt nomina"* or *"post rem,"* that is, they are simply names of common properties (Nominalism)).

This conception and acceptance of pathological entities, not as convenient names of categories, but as an expression of the independent nature of things which are dictated by teleological demands, still control in too large a measure the minds of the medical profession. Thus, through a deplorable lack of philosophical training, medical science stands at present a monstrous anomaly of causal, etiological, symptomatic and transcendent ideas. And thus it has been plunged into a hopeless muddle of definitions and classifications. For this reason I have long insisted that in order to create clearness out of chaos, we should frame our definitions and classifications in pathology, when they fall short to establish causal connections of phenomena, according to unbiased objective (anatomical) descriptions.[3] Helmholtz, the physicist and one of the great experimental physiologists, around the middle of the last century, exclaimed, "Return to Kant." In his great critique of judgment, Kant said, "The purpose [meaning the transcendent power] is a stranger in the natural sciences." And thus he insisted that nature, in order to be intelligible at all, must be explained *physically* through the *intellect*. But Kant also clearly saw that human mind possesses something besides intellect, and thus, while the world is *explained physically* through intellect, it is *interpreted metaphysically* by man's will. Thus Kant properly divides with finest acuteness and with a magnificent grandness of criticism what is intellectual, physical and explanatory in life from what is personal in will and character and assumed. *For the latter does not explain at all but interprets.* It may, therefore, *never substitute for the other* in the *explanation* of things. But even when we resort in the final instance to metaphysical interpretation, we must nevertheless bear in mind that this does not allow any purely imaginary fantastic system, it may not run rampant, but even metaphysics must harmonize, as Wundt insisted, with our intellectual qualifications. Thus Wundt lifted even metaphysics from the position of dreams to a justified philosophical constituent.

The science of pathology and medicine to-day are in bad shape for the reason that their followers are still largely unscientific and

[3] This stand has also long been advocated by Thoma and more recently by Ricker, especially in regard to the inflammatory conception.

not philosophically trained.[4] Sciences atrophy and degenerate when they lose contact with philosophy. Physiology has already permitted light to enter. We find in biophysics a genuine attempt to penetrate through the causal mechanism and to explain construction and functions of the normal living body, according to biophysical laws. Compare the fantastic ideas of Metchnikoff on cell activity with the clear-cut explanations of Rhumbler! Here pathology and even the practice of medicine must follow. Even the practitioner of medicine must be clear in his mind what is meant by logical cause and sequence and what is an auxiliary conception which simply summarizes or interprets but can never explain. He will, then, be less liable to fall for high-sounding therapeutic preparations, or for the rapid practical application of scientific discoveries still under discussion. But he will be better able to properly interpret symptoms and findings in his patient, and he will understand principles of treatment. Until this more profound, philosophical attitude of mind is developed in the practitioner, he will have to compete with osteopaths and chiropractitioners. For he is as crudely empirical, and, therefore, as helpless, as they are, in scientific understanding and treatment of disease. What every practitioner of medicine really needs to-day more than anything else is sound critical judgment of values. He shares that need with almost everybody else in this democratic period. He must every day weigh evidence, which confronts him in his patients and in all the scientific and therapeutic propaganda which meet him daily at the breakfast table through mail and newspapers and by agents in his office. How is he to get judgment of values? There is only one answer! At present, as in the past, not by stuffing him with pseudo science, or feeding him on practical dishes, cooked out of specially prepared scientific food, but through a philosophical consideration and understanding of *all* things, which prepare him to follow and understand independently his own experience and that of others.

The world is everywhere this year celebrating the 200th anniversary of the birth of Immanuel Kant. No other philosopher of recent times has perhaps exercised such deep and beneficial influence on the sciences. As a pathfinder of correct scientific thought and reasoning we owe him the heaviest debt. I offer this as a tribute to him and to the importance of his teaching not only in his own branch but in all spheres of human understanding and knowledge.

[4] Witness the grotesque modern attempts to trace complex *psychic phenomena* directly to the influence of *individual internal secretions* and thus to control them! The abuse of the whole matter of internal secretions has recently been well criticized by J. Bauer, of Vienna. (Individual Constitution vs. Endocrine Glands. Bullet. Buffalo General Hospital. I. 3. 1923.)

THE PHYSICAL BASIS OF DISEASE

By THE RESEARCH WORKER

STANFORD UNIVERSITY

IV. TISSUE OVERGROWTH

"If you wish," said the research worker as the group reassembled in the lawyer's compartment the next morning, "we will take up a fourth group of diseases this forenoon."

"Nothing to do but kill time till we reach Ogden," replied the lawyer.

"I believe you have the right dope as to the kind of facts that should be given the general public," added the manufacturer.

"As our fourth group of diseases, then," continued the research worker, "let us select diseases due to excessive tissue growth in important organs or parts of the human body.

"Probably the simplest example of tissue overgrowth is an ordinary wart. If you cut open a wart and examine its cut surfaces with a magnifying glass, you will find that the wart is composed of an excessive growth of the outer layers of skin. This excessive epithelial growth may form a fairly smooth raised patch on the skin or it may be thrown into folds, forming finger-like or cauliflower-like projections from the skin. Relatively little is known as to the cause of warts. They are probably due to some infectious agent. Wart juice transferred to normal skin will frequently cause warts."

"Then you don't endorse our boyhood fancy that warts are caused by handling toads," said the lawyer.

"You'd be surprised at the number of adults in certain rural communities who are firmly convinced that toads do cause warts. It's a typical example of popular medical ideas based on superficial resemblance. During my boyhood I am sure I never touched a toad until after I had developed a fairly extensive crop of warts. Due to my boyhood reactions to adult warnings, I frequently handled toads after that date. My crop of warts rapidly disappeared."

"Toad homeopathy," said the lawyer. "You should have commercialized your discovery."

"Fortunes are being made to-day by the manufacture and sale of alleged remedies that have originated in a manner similar to this. With a sufficiently aggressive advertising campaign, toad-skin extract undoubtedly could be made commercially profitable."

2

"A slightly more complex example of skin overgrowth is furnished by skin cancers. You have undoubtedly seen numerous individuals with skin cancers, spreading ulcers of the lips or face or other parts of the body. If this skin growth is cut open and its cut surfaces examined microscopically, it will be seen to be composed of an excessive growth of the deeper layers of the skin. This cancerous growth differs from that of ordinary warts in that the finger-like or cauliflower-like processes do not extend outward from the skin surface as in warts, but extend downward and penetrate into the underlying parts. These downgrowths of atypical epithelium gradually kill the underlying tissues into which they penetrate. The nutrition of all but the deeper layers of the cancerous growth is defective, so that the outer portions of the cancer usually die and are sloughed off, leaving the chronic ulcer or open sore with which you are familiar.

"Minute fragments of the finger-like epithelial downgrowths may be detached from the main cancer mass and carried to distant parts of the body. Here they may continue their growth, forming new cancer masses. These secondary cancers may penetrate and destroy important internal organs. Death from skin cancer is usually due to the destructive action of these secondary cancers on important internal parts."

"I have read somewhere that cancer is becoming much more frequent," said the lawyer.

"I believe the number of deaths from cancer in the United States is at present approximately equal to that from tuberculosis. I am not certain, however, that this means a real increase in the prevalence of cancer. Cancer is essentially a disease of advanced age. The average length of life has been materially increased during the last few decades. One would expect statistics to show an apparent increase in all diseases of the later period of life.

"The cause of skin cancer is not known. Hereditary predisposition, chemical injury and mechanical injury are undoubtedly contributory factors. The essential exciting agent, however, is unknown."

"Are there any real cancer cures?" asked the manufacturer.

"No successful therapeutic agent has thus far been found for human cancer. Cancer tissue is less resistant than normal tissue to X-ray and similar agents. Certain external cancers can be successfully killed by X-ray without undue injury to the surrounding normal parts. This method is not generally applicable, however, to more delicate internal organs. The only dependable cancer cure is radical surgical removal. If done early in the disease, before sec-

ondary internal cancers are formed, it is a successful method. After invasion of internal organs, however, cancers are practically incurable. Numerous alleged cancer cures, however, are on the market."

"I have an acquaintance who had cancer of the stomach," said the manufacturer. "She was cured by such a remedy."

"I will wager any amount of money that the facts of the case are not as you have understood them. The facts are probably about as follows: You have an acquaintance. She had certain symptoms. She thought these symptoms came from her stomach. In some way she got the idea into her head that she had cancer. She purchased six bottles of an alleged cancer cure. Two months later her symptoms disappeared. She then claimed she had been cured of cancer. Hundreds of such claims have been investigated. There is not a single authentic case on record of a cancer cured by a commercially exploited remedy. Thousands of autopsy records substantiate this conclusion. The same thing is true of the numerous alleged cures of cancer by the various forms of religio-therapy."

3

"In addition to local skin overgrowths illustrated by warts and cancers, there are numerous examples of excessive growth of the skin as a whole. One of the best illustrations of this takes place following the surgical removal of the thyroid gland. In these cases the skin becomes markedly coarsened in texture, and greatly increased in thickness. The face becomes puffy and expressionless. On microscopic examination the increased thickness of the skin is seen to be due to a general overgrowth of the deeper skin layers, with jelly-like deposits in these layers.

"This skin overgrowth can be arrested, and usually the skin restored to normal by the administration of thyroid extract. This skin overgrowth is therefore but one effect of insufficient amounts of thyroid gland in the body."

"It doesn't seem credible," said the manufacturer, "that a small gland in the neck can produce such marked changes in such a tough structure as the skin."

"A small amount of iodin is present in all living plants and animals. Iodin is apparently necessary for the normal growth of all human tissues, including the skin. If we look upon the thyroid gland as the main organ in which iodin, taken in as food, is prepared for the use of other tissues, we can understand how disturbed thyroid function can influence skin growth. Whether or not this conception is in accord with the actual chemical facts of the case has not been fully determined."

"I should think that would be a problem very easily settled by an expert chemist," said the lawyer.

"This problem is typical of numerous unsolved problems in research medicine. Rapid progress would be made in the solution of these problems if there were adequate financial support and social recognition for research workers. Most of the important scientific advances of the past have been made by young men during the few years necessary to build up a practice or obtain other remunerative employment. Very few mature medical workers have been able or willing to continue in the research field.

"Except in Germany," said the manufacturer.

"Germany's former world lead in certain lines of medical research was mainly due to the official honors and social recognition given to research workers. Mature men of high attainments were attracted to this field.

"We surely ought to interest some of our American live wires in this game," said the manufacturer.

"The typical 'live wire' is useless as a research worker. He's equally unsuccessful as a director of research. A quite different type of man has been responsible for the important scientific advances of the past."

"How about K——?" asked the lawyer. "The papers are full of his discoveries."

"Very successful in selling himself to the general public. His spectacular results, however, almost without exception have been quietly disproved by competent laboratory workers. One must discount 95 per cent. of all medical discoveries announced in the daily press.

"There are numerous other examples of tissue overgrowth in one part of the body resulting from abnormal activity of a remote gland. One of the most striking of these is excessive growth of the bones that occasionally takes place, enormous enlargements of the hands and feet, and weird distortions of the features. This is the disease known technically as acromegaly. There is conclusive evidence that the excessive bone growth in this disease is due to overactivity of a small gland at the base of the skull, the pituitary gland. This gland apparently forms or secretes substances that serve as normal stimulants to bone growth. Partial removal of the pituitary gland in early life results in a stunted growth of the bones, the formation of dwarfs. These effects have been extensively studied on animals.

"Excessive bone growth, however, can apparently be produced in other ways. A familiar example is the enlargement and distortion of the joints in certain types of 'chronic rheumatism.' The cause of these joint enlargements is not known."

"I thought rheumatism was a germ disease," said the manufacturer.

"The term 'rheumatism' is popularly applied to numerous diseases giving pain in the joints or extremities. Certain forms of rheumatism are due to infectious agents. The cause of the excessive bony overgrowths in the form of chronic rheumatism I have in mind, however, is unknown. Autopsies indicate that the bony overgrowth is probably not dependent upon pituitary abnormality. The disease has never been reproduced in lower animals, hence little progress has been made in discovering the real cause."

4

"Tissue overgrowth is one of the commoner forms of disease in internal organs. A good example is the formation of wart-like processes on the heart valves. These finger-like or cauliflower-like outgrowths on the valves are usually the result of the local action of disease-producing microorganisms. The wart-like masses may be so large as to seriously handicap the heart, either by interfering with the forward passage of blood or by preventing the normal closing of the valves so that backward leakage takes place.

"One of the serious dangers arises from the tendency of these wart-like masses to rupture. Small fragments of the mass may plug important arteries in other parts of the body. Autopsies in cases of such valvular outgrowths often show large areas of important organs killed, liquefied, partly absorbed or partly or completely replaced by scar tissue as a result of the plugging of local arteries. Paralysis or sudden death may result from the plugging of certain brain arteries.

"Probably the most common tissue overgrowth in the circulatory system, however, is excessive tissue growth in the walls of the blood vessels. The delicate lining of the blood vessels is often stimulated to excessive growth by the action of toxic or infectious agents. The lining may become several times its normal thickness.

"This increased thickness of the lining of the blood vessels is without appreciable mechanical effects in the larger arteries. In the smaller blood vessels, however, the increased thickness materially narrows the blood vessel and may even lead to its occlusion. In this way numerous minute blood vessels may be reduced to solid cords, through which blood can not circulate. This greatly reduces the nutrition of the parts supplied. It usually leads to marked degeneration of these parts. The degenerations of the nervous system in late stages of syphilis, for example, are often due to partial starvation and asphyxiation of the nerve cells from such blood vessel narrowing."

"I wonder if many people realize that syphilis can cause such changes as this," said the lawyer.

5

"Numerous examples of tissue overgrowth are found in the respiratory system. One of the most striking of these is the formation of secondary cancer nodules in the lungs. Small fragments of skin cancer, for example, may be carried to the lungs and there lodge in the minute blood vessels. These minute cancer fragments may continue to grow in their new location. They gradually penetrate and destroy the surrounding lung tissue. It is not uncommon at autopsy to find a lung containing a hundred or more cancer masses varying in size from a pea to that of a small orange.

"An interesting example of tissue overgrowth in the lungs takes place in syphilis. Here the walls of the air sacs may be thickened by excessive tissue growth. This overgrowth greatly reduces the size of the air spaces and may even lead to their obliteration. The thickened walls also interfere with the normal interchange of oxygen between the circulating blood and the inspired air."

"Tissue overgrowth is also common in the digestive system. Wart-like masses, for example, may form in almost any part of the gastro-intestinal tract. They are often so large as to seriously interfere with the passage of food.

"Probably the most important tissue overgrowth in the gastro-intestinal tract, however, is cancer formation. A frequent site of primary cancer is the junction of the stomach and intestine. Autopsy will usually show this junction changed to a solid mass of cancer tissue, firmly attached to adjacent organs. On cutting open this mass, the passage from the stomach to the intestines is usually found markedly narrowed, even completely obliterated.

"Aside from mechanical interference with the passage of food, a fairly common effect of cancer growth in this locality is mechanical interference with the excretion of bile. The bile duct, as you know, enters the intestine near its junction with the stomach. This duct is often narrowed or compressed by the cancer mass. This causes a damming back of the bile into the liver, with its absorption by the circulating blood. The yellowish pigmentation of the skin often seen in such cases is usually due to such bile absorption."

"What's the real dope on the surgical treatment of such cancers?" asked the manufacturer.

"If gastric cancer is recognized at an early stage, before it sets up secondary nodules in surrounding parts, the cancer growth can often be completely removed, with fair chances of a permanent cure. After invasion of surrounding organs, however, it is often impossible for the surgeon to find or to remove all the cancer frag-

ments. The minutest unremoved fragment will eventually cause death of the individual.

"A somewhat different example of tissue overgrowth in the digestive system is giantism of certain portions of the gastro-intestinal tract. Giantism, for example, is fairly common in the stomach. A stomach may be so enlarged as to almost completely fill the abdominal cavity. Or, it may be of approximately normal size, but with walls several times the normal thickness. A frequent cause of stomach giantism is increased resistance to the passage of food from the stomach to the intestines. The enlarged stomach is usually more or less incapable of causing proper movements of the food. Stagnation, fermentation and putrefaction of food may take place."

6

"Very striking symptoms may be caused by tissue overgrowth in the nervous system. A good example of such overgrowth is an increase in the thickness of the meninges or sheath surrounding the brain and spinal cord. This sheath, for example, is occasionally locally thickened, forming a firm ring or collar about the spinal cord. This collar may so constrict the spinal cord that degenerations and even death of the underlying nerve cells take place, causing various sensory disturbances and paralytic symptoms.

"The commonest tissue overgrowths in the nervous system, however, are tumor masses. These usually arise from the supporting tissues of the brain or spinal cord, rather than from the nerve tissue itself. The tumor masses mechanically compress and irritate adjacent parts, causing nerve cell degeneration and in extreme cases nerve cell death. Our present knowledge of brain localization has been largely derived from a comparison of the clinical symptoms and subsequent autopsy findings in such cases. One of the common effects of such tumor masses is increased pressure within the skull cavity. This mechanically interferes with the circulation and nutrition of the brain.

"Cases are on record of marked overgrowth of the brain as a whole. I am not certain that microscopic examinations were made in these cases. I do not know whether the increased brain weight was due to a real overgrowth of nerve tissue or was only an apparent increase from excessive amounts of fluid and supporting tissues. I believe the largest brain on record weighed over twice that of a normal individual. It was the brain of an idiot."

"We must be entering the outskirts of Ogden," said the manufacturer.

"Our last real breathing spell before we reach the coast," said the lawyer.

OCCUPATIONAL DIFFERENTIAL FECUNDITY

By HORNELL HART

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CERTAIN eugenists have taken a highly alarmistic attitude toward the future of the race. Thus C. S. Saleeby writes of British conditions:

> A steadily and rapidly diminishing proportion of the nation's children are being born to parents, and in environments, such as promise them the best inheritance, both biological or genetic, and social. . . . Evidently a very very few generations of this, which is typical of the whole nation, must be fatal. School clinics are blessed and precious things, but they are less than a forlorn hope in such a racial tragedy as this. . . . I believe that, if this practice (race suicide) continues, our race in these islands is doomed.

Similarly pessimistic as to America is Lothrop Stoddard. He says:

> If intelligence continues to be bred out of the race at its present rate, civilization will either slump or crash from sheer lack of brains.

The argument used by the eugenists involves four steps, which may be summarized as follows:

(1) The more highly educated classes; the professional classes, and the more successful business classes are reproducing at much lower rates, and with longer intervals between generations, than are the unskilled, ignorant and poverty-stricken classes.

(2) The highly educated, professional and more successful business classes average far higher in desirable characteristics—particularly in intelligence and energy and in the capacity to provide wholesome child environments, than do the unskilled, ignorant and poverty-stricken classes.

(3) These desirable characteristics are transmitted from parents to children through social and biological heredity.

(4) From the above premises it would follow that average intelligence and average social desirability in general, in so far as they are socially hereditary, will have a strong *tendency* to decline and in so far as they are *biologically* hereditary will be *bound* to decline from generation to generation until the disgenic differential fecundity of these classes is altered. Put into other words, the conclusion derived from the above premises is that the rapidity of human reproduction is inversely correlated with the quality of the

germ plasm, and inversely correlated with the quality of the culture of the individuals reproducing, and that this inverse correlation means progressive deterioration of the race.

If this conclusion is justified it far outshadows in ultimate significance the great majority of problems to which humanitarians and social research workers give attention. Yet, although great quantities of statistics have been collected on differential fecundity, there seems to be available no reliable quantitative estimate of the speed with which the race is approaching its disgenic doom. The specific question which needs a definite answer is: how much decline in racial quality is occurring per decade through differential fecundity?

Because of gaps and defects in existing data, no adequate answer can be given to this broad question. The present paper attempts to indicate the answer to a narrower query; namely, how much lower in ability to pass mental tests is the rising generation than it would have been if fathers in various occupations had had the same average number of surviving children? What is the effect (in other words) of occupational differential fecundity upon the mental-test ability of the rising generation?

With regard to the fact that the higher occupational groups are reproducing much more slowly than the lower occupational groups, comprehensive and fairly conclusive statistics have recently become available for the United States registration area, in the census analysis of data from birth certificates for 1920. From these tabulations it is clear that the wives of men in the least skilled occupations not only have had decidedly more children born to them than the wives of more highly skilled and better educated men have, but the number of *surviving* children in the lower occupational groups is markedly greater than the number in the higher occupations.

These tabulations by the United States Census Bureau are based upon such large numbers of cases that the contrasts which they show in fecundity between occupations can not be due to chance. It is a striking fact, moreover, that data collected in Scotland, by different methods, at a different date, strongly corroborate these figures relating to the United States. For 39 comparable occupations the correlation between the number of children born per wife in these American families and the number born per completed marriage in Scotland, is plus .84 with a probable error of .05. This high correlation indicates that, in spite of the differences between social conditions in Scotland and in the United States, and between the statistical methods employed, the data for the two countries correspond with each other to a surprising degree. The

sizes of families for certain important occupations are shown in Table 1. In both America and Scotland the better educated and

TABLE I

FECUNDITY AND OCCUPATION

In Scotland and in the United States

Occupation	Average number of children born: *Scotland* (Completed families)	*U. S.* (Uncompleted families)	Average number of living children *U. S.*
Professional			
Dentists	3.9	2.0	1.9
Technical engineers	4.4	2.1	1.9
Teachers	4.2	2.3	2.1
Lawyers	3.9	2.4	2.2
Clergymen	4.3	3.3	3.0
Mine owners	6.4	3.2	2.9
Skilled workmen			
Electricians	5.0	2.3	2.1
Printers	4.9	2.5	2.3
Plumbers	5.4	2.8	2.5
Painters	5.6	3.3	2.9
Carpenters	5.6	3.5	3.1
Rural			
Farmers	6.2	3.8	3.4
Agricultural laborers	6.4	3.5	3.0
Unskilled laborers			
Garbage men	6.2	3.4	2.9
General laborers	6.3	3.7	3.1

The sources of data for the above table are: Dunlop, James Craufurd, "The fertility of marriage in Scotland," *Journal of the Royal Statistical Society*, 77 (1914), 259–288; United States Census, Birth Statistics, 1920, p. 18.

more successful occupational groups have decidedly fewer children born. Laborers' families in both countries have from 50 to 100 per cent. more children than the families of professional men. It is true that clergymen in the United States have nearly as large families as laborers, and that mine owners in both countries have strikingly large families. In general, however, it seems clear, as a great many other statistical studies have indicated, that the occupations requiring the longest educational preparation have the smallest families.

The next step in the inquiry is to determine what differences, if any, exist in the mental-test ability of the children having fathers in the various occupational groups. The term "mental-test abil-

ity'' is used in this paper instead of the term ''general intelligence.'' The problem of what mental tests really measure is not involved in this argument. Whether the ability to get high scores in these tests is due to innate excellence of one's brain cells, or to the excellent vocabulary and the training given by one's parents, the arguments and conclusions of the present discussion are equally valid. There is a fairly specific sort of ability measurable by mental tests, and known to be important in connection with success in life. Is the mental-test ability of the American people declining as a result of differential fecundity between occupations? If so, how rapid is the rate of that decline?

Several independent investigations throw light upon the differences in the mental-test ability of the children of fathers in different occupational groups. In the three cities in which are located the universities of Ohio, Indiana and Wisconsin, studies have severally been made by psychologists from those universities to determine the comparative abilities of the children of men of different occupational levels. In each of the three studies the children of professional men average by far the highest in mental-test ability, the children of business men next highest, skilled workmen's children next and the children of unskilled laborers lower than any of the above three occupational groups. The Indiana study places children from rural districts distinctly lower than children of unskilled laborers, but the investigation included an abnormally poor rural area. The Wisconsin study puts the children of farmers markedly higher than those of unskilled laborers, but the number of farmers' children tested in that study was only 60, and there is some reason to think that the children of farmers attending school in Madison may be a selected group. An intensive study of a typical rural area by the Iowa Child Welfare Research Station places the children of farmers slightly higher in intelligence quotient than the children of unskilled laborers. The results of the Indiana, Columbus and Madison studies are summarized in Table 2.

Although these three studies were made in different states, with different tests, by different investigators and although the results are stated in quite different statistical units, the conclusions reached are strikingly unanimous. There can be no question that the occupational groups with higher standards of living and smaller families do produce children with decidedly higher mental-test ability on the average than the occupational groups with lower standards and larger families.

On the basis of the data thus far presented it must be conceded that disgenic differential fecundity between occupations does exist. Table 3 brings together for the broad occupational groups the sizes

TABLE II

CHILDREN'S MENTAL-TEST ABILITIES IN RELATION TO FATHERS' OCCUPATIONS

Occupations	*Indiana* study	*Columbus* study	*Madison* study
Professional	83	1.42	114
Business	66	1.26	104
Skilled trades	47	1.22	97
Unskilled labor	39	.83	89
Farming	27	.....	94
Number tested	1,206	228	2,782

The statistical units employed in the above studies were: in Indiana the percentages of children above the median scores for their ages in the Pressey tests; in Columbus the coefficient of mental ability based on the Yerkes-Bridges Point Scale; in Madison the intelligence quotients based on the Dearborn and National Intelligence Tests.

The sources of the data in the above table are: Pressey, S. L., Luella, W., and Thomas, J. B., "A study of country children," etc., *Journal of Applied Psychology, 3* (1919), 283–286, *4* (1920), 91–96; Pressey, S. L., and Ralston, Ruth, "The relation of the general intelligence of school children to the occupation of their fathers," *Journal of Applied Psychology, 3* (1919), 366–373; Bridges, J. W., and Coler, Lillian E., "The relation of intelligence to social status," *Psychological Review, 24* (1917), 1–31; Dexter, Emily Smith, "Relation between occupation of parents and intelligence of children," *School and Society, 17* (1923), 612–616.

TABLE III

DECLINE IN MENTAL-TEST ABILITY

Due to Occupational Differential Fecundity

Occupations	Average Number of *Living Children*	*Average I. Q.* of Children
Professional	2.2	114
Business and clerical	2.5	104
Skilled trades	2.6	97
Farming	3.4	91
Unskilled labor	3.1	89
Average I. Q. of families		94.3
Average I. Q. of children		93.7
Difference due to differential fecundity		.6

of families and the average intelligence quotients of the children. The figures therein shown are weighted averages built up from finer occupational classifications. From the data here summarized it is possible to get a first approximation of an answer to our question as to the effects of occupational differential fecundity upon American intelligence. Suppose that we enter for every family that reported having had a baby in the registration area in 1920 the average intelligence quotient of children having fathers in cor-

responding occupations. If these intelligence quotients are added up and divided by the total number of families reporting births, the result will be the best available estimate of what the average mental-test ability of the children of these fathers would have been if the average size of families in the various occupations had been uniform. This average intelligence quotient, which counts each family only once, is 94.3. If we assign to *each living child* of the fathers reporting babies in 1920 the intelligence quotient found for children of fathers in corresponding occupations, and divide the total of these intelligence quotients by the total number of living children, the result will be the best available estimate of the mental-test ability of the living children of these fathers under actual conditions. This average is 93.7. The difference between these two averages is six tenths of one point I.Q. In other words, the average mental-test ability of the living children of these fathers is six tenths of one point lower, in terms of intelligence quotients, than it would have been if every occupation had had the same average number of living children per father.

While the above method gives a first approximation of an answer to our question, it involves certain statistical imperfections and it fails to reflect the full effect of differential fecundity because it takes into account only *occupational* differences in size of families. It is just as significant if brilliant lawyers have smaller families than stupid lawyers and if intelligent laborers have smaller families than stupid laborers as it is if lawyers have smaller families than laborers. Comparisons *within* occupational groups are just as significant as comparison *between* occupational groups. Differential fecundity between families is the important thing to measure. The occupational group is merely a somewhat clumsy statistical intermediary for arriving at approximate results.

To avoid these difficulties involved in the method of occupational differential fecundity, the writer is now making a survey of 500 typical families in Davenport, Iowa, in which the number of surviving children in approximately completed families will be correlated with mental-test ability, school progress and certain very carefully determined measures of important character traits. When a sufficient number of such studies have been completed in typical American communities they will make available for the first time accurate quantitative data for answering the question as to the effects of differential fecundity upon racial quality in this country.

In the meantime it can be said with confidence that differential fecundity between occupational groups is having a rather slight, but unquestionable, depressing effect upon the mental-test ability of the rising generation in the United States.

HIGHER MENTAL AND PHYSICAL STANDARDS FOR IMMIGRANTS

By Professor ROBERT DeC. WARD
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Foreword

The Immigration Act of 1924 established a new American immigration policy. It marked "the passing of the dominating factor of economics and established for the future American policy the basic elements of racial values and family stock quality."[1]

Within certain limits, which are rather vague because of an at present unknown number of "non-quota" immigrants, we have decided to admit only a limited number of new aliens, and the bulk of these are to be of the same racial stocks as those which originally settled and developed our country, founded our institutions, framed our constitution and to-day still make up the bulk of our population. Until we had set some sort of numerical limitation on immigration, better selection—mental, physical or economic—was impossible. That very important first step having finally been taken, it now becomes our duty, both to ourselves and to coming generations of Americans of whatever racial origin, to set higher mental and physical standards for all our future immigrants. It is an absolutely illogical and indefensible situation that our regulations governing the admission of animals and plants are to-day, and have been for years, far more stringent than our immigration laws, and have been more strictly enforced.

It is the aim of the present paper to consider briefly: (1) what legislation has already been enacted to exclude eugenically undesirable immigrants; (2) how these laws have worked, and (3) what further amendments have been suggested in order to bring about a better selection of immigrants on mental and physical grounds.

The General Immigration Act of 1917

The general Immigration Act of 1917 enumerates all the classes of aliens which Congress has so far declared shall be excluded because eugenically undesirable. In respect to these classes the act of 1917 remains in force, not having been superseded by the new act of 1924. The aliens thus specifically debarred under Section 3 are the following: idiots, imbeciles, feeble-minded persons; epileptics;

[1] *Eugenical News*, July, 1924.

insane persons; persons who have had one or more attacks of insanity at any time previously; persons of constitutional psychopathic inferiority; persons with chronic alcoholism; persons afflicted with tuberculosis in any form or with a loathsome or dangerous contagious disease; persons not comprehended within any of the foregoing excluded classes who are found to be and are certified by the examining surgeon as being mentally or physically defective, such physical defect being of a nature which may affect the ability of such alien to earn a living. In order to prevent so far as possible the bringing or landing of any aliens belonging to the above excluded classes, certain fines are imposed upon the transportation companies in cases of violation of the law, if it appears to the satisfaction of the secretary of labor that any alien so brought was afflicted with any of the specified diseases or disabilities at the time of foreign embarkation, and that the existence of such disease or disability might have been detected by means of a competent medical examination at such time. In addition, the company has to pay a sum equal to that paid by the alien for his transportation from the initial point of departure to the port of arrival.

In order to determine whether any alien belongs to any of the excluded classes such alien may be kept on board ship or at an immigration station long enough to enable the medical officers to reach a definite conclusion in the matter.

The act specifically and definitely provides that the decision of a board of special inquiry (which acts on the cases of all aliens who do not appear to the examining inspector to be clearly and beyond a doubt entitled to land) "shall be based upon the certificate of the examining medical officer, and, except as provided in Section 21, shall be final as to the rejection of all aliens afflicted with tuberculosis in any form or with a loathsome or dangerous contagious disease, or with any mental or physical disability which would bring such aliens within any of the classes excluded from admission to the United States under Section 3 of this act."[2] These are known as the *mandatorily excludable* classes. Section 21 here referred to as containing the exceptions, *i.e.*, as specifying the only cases in which the certificate of the medical officer may not be final as the cause of debarment, provides that any alien liable to be excluded because (1) likely to become a public charge, or (2) because of physical disability other than tuberculosis in any form or a loathsome or dangerous contagious disease, may be admitted in the discretion of the secretary of labor upon the giving of a suitable bond. The only appeal of an alien certified for insanity or mental defect is to a board of medical examiners (Section 16). Appeals from the

[2] Section 3 names the excluded classes, as above indicated.

ordinary decisions of the boards of special inquiry are to the secretary of labor. Every adverse decision may be thus appealed. Section 19 provides that aliens who at the time of entry belonged to one or more of the classes excluded by law, or who entered the United States in violation of the law, shall, upon the warrant of the secretary of labor, be taken into custody and deported.

These are the specific provisions of our immigration law with reference to the exclusion of eugenically undesirable aliens.

Why Eugenically Undesirable Aliens have not been more Effectively excluded

Complete and satisfactory as the act of 1917 seems to be, it has not accomplished its purpose. *It has not in the past been rigidly enforced.* Every one who is at all familiar with immigration problems knows that, and especially the aliens themselves, their relatives and friends in this country and the steamship companies. There have been admitted not hundreds but thousands of aliens who were diseased; who were mentally and physically far below par; who had criminal records and tendencies; who could not earn their own living; who were in every way hopelessly undesirable and impossible material for American citizenship.

There have been three main reasons why the many excellent eugenical provisions in our immigration law have not been enforced. These are (1) the lack of enough thoroughly competent and well-paid inspectors; (2) the impossibility of detecting, in the usually hurried and superficial examination at the port of arrival, nearly all the cases which for one reason or another should be debarred; (3) the abuse of the privilege of appeal from the decision of competent medical officers and of the boards of general immigration inspectors, and the far too great leniency in sustaining such appeals in the office of the secretary of labor.

The decrease in numbers and the improvement in quality of our immigrants which will result from the new Immigration Act of 1924 should help greatly to make the medical examination of arriving aliens more thorough, and thus lead to the detection of more of those who belong in the mentally and physically defective classes. In other words, the difficulties noted under (1) and (2) above ought to be lessened. The third difficulty, noted under (3), will remain unless those who are concerned about the future mental and physical condition of our people take hold of this problem and see to it that what has happened in the past shall hereafter no longer be possible. The appeal and bonding clauses of the act of 1917 give the secretary of labor authority, in his discretion, to reverse the decisions of the boards of special inquiry, and also to permit aliens

suffering from certain diseases or disability, or likely to become public charges, nevertheless to enter the United States for a limited time, under bonds, for treatment or observation, or to give them opportunity to prove that they will not become public charges. In theory, this is a very humane and just provision. In the opinion of unprejudiced students it is one of the biggest holes in our general immigration law. Under these clauses far too many aliens mentally and physically defective and certain to become public charges have been admitted. Appeals are constantly made on behalf of every class of alien specified in the law as excludable. Immigrant "aid" and charitable societies; immigrant lawyers who prey on the alien; relatives and friends of those liable to be debarred; senators and congressmen of the United States and city and state politicians more interested in securing a few votes from their foreign-born constituents than in the future character of our race; misguided sentimentalists, appeal in behalf of the detained alien. The United States usually has everything to lose and nothing to gain if the appeal is sustained. The only safeguard which the country has is in the honest and patriotic officials of the Immigration Service, who, in the face of terrific pressure, endeavor to uphold the law. The result has been that aliens certified by thoroughly competent expert medical officers as having such mental or physical defects as constitute them potential public charges and highly undesirable elements in our population have been admitted, on appeal or under bonds. As Hon. Robert E. Tod, recently commissioner of immigration at Ellis Island, has said, "It is an insult to the intelligence of the examining boards of medical officers to reverse their decisions over and over again under political pressure."

The situation regarding aliens who are certified as having physical defects which in the opinion of the medical officers may affect the ability of the alien to earn a living needs a few words of comment. The provision adding to the excluded classes (1907) those certified as being mentally and physically defective, the defect being of such a nature as to affect ability to earn a living, has proved of comparatively little value eugenically. Those who drafted this provision intended it to be a medical test, but it was very soon decided that the medical certificate in such cases was only one piece of evidence to be taken account of by the board of special inquiry as bearing on the question of the ability of the alien to earn his living. In other words, the provision became an economic, not a medical test. Most of the cases admitted on appeal have been those of aliens with a medical certificate of this character, but where other circumstances seemed to warrant admission.

The remedy for this situation is obvious: (1) No immigrants belonging to the class of *mandatorily excludable* aliens (*i.e.*, those

suffering from idiocy, insanity, imbecility, feeble-mindedness, epilepsy, constitutional psychopathic inferiority or chronic alcoholism) should ever be admitted.[3] (2) There should be no yielding to political pressure for the admission of aliens on appeal over the decisions of the medical examiners and the boards of special inquiry. As a recent writer has said, "any intervention by a politician in behalf of an excludable alien should be regarded as a strong presumption that the case should be dropped at once, and the alien deported forthwith." (3) The whole policy of admitting aliens who are not *clearly* and *beyond question* entitled to land—border-line cases—must be stiffened up all along the line. Appeals from adverse decisions of the boards of special inquiry should rarely be sustained. Aliens suffering from a physical or mental disability which makes them potential public charges should always be excluded unless there are very strong reasons to the contrary. The appeal and bonding provision as it stands at present can be, and has been, used to nullify many of the excellent eugenical clauses of the law. American public opinion must arouse itself and insist on a rigid enforcement of this law. As things now stand, alien interests and alien influences and alien "pressure" working—to their shame be it said—through American senators and congressmen are active day and night to secure the admission of immigrants whom Congress has declared inadmissible.

One reason for the laxity in the enforcement of the law is that there is a very widespread idea that "the United States should not separate the families of aliens" when an imbecile or a feeble-minded or other excludable member of the family arrives at our ports. But it should be remembered that in the large majority of such cases, the alien family intentionally separated itself overseas, when some members of the family, knowing perfectly well the provisions of our law, came over first, established a foothold, and then sent for the feeble-minded or imbecile or diseased son or daughter, mother or aunt, uncle or nephew. The vast majority of our immigrants know our immigration laws far better than most Americans do and deliberately "work" the sentimental plea in favor of the admission of the undesirable child or relative. It is very easy to arouse tremendous sentiment in individual cases of apparent hardship. A brief paragraph in a daily newspaper is all that is necessary to bring that about. The far larger interests of the United States, which suffer through the admission of mentally and physically unfit aliens, are more remote, and hence attract little or no attention.

[3] Recommendation of Interstate Conference on Immigration, New York, Oct. 24, 1923.

The Immigration Act of 1924

Although the Immigration Act of 1924 contains no specific provisions looking towards a more rigid exclusion of eugenically undesirable aliens, it will accomplish a better selection than has hitherto been possible. It will accomplish much more than a change in the racial character of our future immigration, tremendously important as that change will be. It will also bring about a distinct improvement in the mental and physical conditions of our immigrants. As Dr. Wm. J. Mayo truly said in an address at the Boston City Hospital, November 14, 1923, before the new act was passed:

> The alien is a public health problem, just as he is a social problem, and the public hospital sees the dark side of this picture. In the American of several generations, the doctrine of moral obligation has become thoroughly ingrained. In southern Europe the Oriental point of view more or less prevails that no obligation which is not enforcible exists. The laxity of the conduct of the law in the United States, the slowness of justice, and the extraordinary latitude allowed the offender against the community, give the criminal more than a sporting chance to escape punishment and have exposed the administrators of law to the contempt of the class of offenders brought to us in recent years by immigration. And these are the people with whom our public hospitals are overcrowded. Our courts have been filled with alien lawbreakers until the people have arisen in righteous indignation and reduced the number of immigrants to 3 per cent. of the number already here from each country. If the percentage system of immigration in effect in 1890 could be reverted to, as has been advised, a much more desirable class of citizens would be brought from the countries that gave birth to the United States and its concept of government.

The new Immigration Act will not only bring us (1) a limited, more homogeneous and more easily assimilated immigration, but (2) an immigration of generally higher intelligence than has characterized the bulk of the people who have come here in recent years and (3) greatly reduced numbers of aliens belonging to many of the "socially inadequate" classes. The original argument in favor of a percentage limitation was economic. The fundamental reason for its continuance is biological.

The act of 1924 contains a new provision—that of immigration visas—so important that if it contained nothing else the time and the labor involved in its preparation and discussion would have been well spent. For many years students of immigration have advocated some sort of preliminary inspection of intending immigrants overseas, before they start on their journey, as a necessary and a humane measure—a benefit to the United States and a means of preventing unnecessary hardship to the alien. The new law embodies the first practical attempt which the United States has ever made to conduct a preliminary selection abroad with a view to weed-

ing out at least some of those who are debarred by our present laws. Complete overseas inspection, general and medical, is impossible owing to the limited jurisdiction of our consular service under the existing treaties, and because foreign governments have objected to our taking such a step. But foreign governments can hardly object to the requirement in the new law of having the intending immigrant fill out a questionnaire before an American consul, showing whether or not, according to his own statements, he is qualified for admission to the United States under our laws.

The essentials in the new plan are as follows: Aliens entering the United States must have passports from their home government, viséed by an American consul. Hitherto the visa could be withheld only if the alien was known or thought to hold views inimical to organized government. Consular officers could exercise no discretion in the matter of giving visas to prospective immigrants, even when it was certain that the aliens would not be admitted or, if admitted, would be most undesirable additions to our population. Under the new law, a consular officer abroad has a real discretionary power of selection, for he may refuse to issue an immigration visa "if he knows or has reason to believe that the immigrant is inadmissible to the United States under the immigration laws." The consul's action is final. Every immigrant must bring with him his passport and its accompanying visa. Before securing the visa, the alien must answer a very full questionnaire, essentially the same as that which he is asked on his arrival here, intended to show whether he is eligible for admission under our laws. This document includes the question whether the alien or either of his parents has ever been in an institution or hospital for the care and treatment of the insane, must also be accompanied by the alien's *dossier* and prison and military record, and must be sworn to before the consul.

While there will undoubtedly be many cases of perjury and of fraud in this connection, there can be no question that a very great many undesirable aliens, excludable by law, will be headed off by our consuls when application is made. This plan will reduce hardships to the absolute minimum; avoid the division of families; save the nationals of other countries the expense, perils and hardships of the ocean trip to the United States only to find that for some reason the immigrant or some member of his family can not enter. Certificates are to be issued only up to the numbers allowed by the quotas, and are good for four months, so that if an alien comes at any time within that period he will not be denied admission as being in excess of the quota allowance. This provision also stops the rush of aliens at the beginning of each month, and makes pos-

sible a more deliberate and more thorough medical inspection—an improvement very greatly to be desired. The real inspection, medical and otherwise, will be made at our own ports, as it should be, but many of the aliens who would be excluded on examination here will never start on their journey. The certificate plan, then, will, through the preliminary selection overseas, benefit the United States. It will also very greatly diminish the hardships of the alien. It is selective. And it is humane.

Three other clauses in the Act of 1924 deserve mention because of their eugenic importance: (1) The fines on the transportation companies for bringing inadmissible aliens are very considerably increased and this will greatly help in the enforcement of the law; (2) any alien who at any time after entering the United States is found to have been at the time of entry not entitled to enter or to have remained here for a longer time than permitted shall be deported; (3) alien seamen must be detained on board ship until they have submitted to inspection, including a medical examination. With certain exceptions, alien seamen found excludable are prohibited from landing.

The new law is a long step forward along eugenic lines, and as such deserves hearty support on the part of all who desire that the immigrants who come to us shall be physically, mentally and morally sound and desirable progenitors of future Americans. Various suggestions put forward from time to time by close students of immigration problems who are especially concerned about the eugenical selection of our immigrants have, however, not yet become part of our immigration policy. These deserve careful consideration at this time.

I. Cash Bonds

Reference has already been made to the provision in the act of 1917 which permits the secretary of labor to admit certain classes of aliens under bonds, and to the evils which have resulted from the abuse of this bonding privilege.

The way the bonding provision actually works out is this. The bonds are usually in amounts between $500 and $1,000. They are taken out through a surety company by a relative or friend of the alien, or by some immigrant aid society. For many reasons, in most of which the relative or friend plays the chief part, the alien admitted on appeal has too often been "lost." Change of residence, change of name, and removal to another state have been common schemes for bringing this about. In many cases the relatives or friends have been willing enough to care for the admitted alien for a time, but soon lost interest, and were quite ready to have their

bonded fellow-countryman taken care of by the community. The bonds are for too small amounts. They can not always be enforced. They have too often become mere "scraps of paper." A large percentage of all bonded aliens have in the past violated and forfeited their bonds and are now here, some in public institutions; some supported more or less of the time by public or private charity, and most of them at large in the community, a social menace because, themselves in many cases mentally defective, they have been producing mentally inferior children. The "paper" bonding system has worked incalculable injury to our population.

This situation, recognized as such by competent and unprejudiced authorities on immigration, should be remedied. (1) Aliens belonging to the "mandatorily excludable" classes should never be admitted on appeal over the heads of the medical examiners, as has been urged earlier in the present article. And (2) in all other cases when aliens are admitted on appeal *cash* bonds in substantial sums *should be required.*

Section 21 of the Act of 1917, which provides for bonding, expressly states that in lieu of other ("paper") bond, any alien "may deposit in cash with the secretary of labor such amounts as the secretary of labor may require, which amount shall be deposited by said secretary in the United States Postal Savings Bank." If the alien became a public charge, the money would be directly available towards the expenses of his support; and no suit to recover would be necessary. As things stand now, the expense of suing, on the part of any state or municipality or town, is usually too great to make it worth while to institute proceedings for the recovery of the money, the amount of which is usually far too small. A $1,000 bond should be the minimum, and $5,000 would not be too much in many cases.

In connection with cash bonds several points should be kept in mind. Congress has already approved them as an alternative to paper bonds. A cash bond is a perfectly fair requirement in the case of any alien who is given the special privilege of being admitted contrary to law, for the United States is taking a decided risk in admitting him. If, at the end of say five years, the alien appeared and gave proof that he had not become a public charge, the capital sum of the deposit, plus interest, should be returned to him. In case he did not appear, the United States could use the money for hunting him up, and for deporting him if found. As things stand under our present bonding system, the government too often does not attempt to find an alien who has forfeited his bond because of the expense involved and the difficulty or impossibility of locating him. If a cash deposit of a considerable amount were

required, the relatives and friends of the alien and the immigrant aid societies would be much less ready than they now are to appeal the cases of excluded aliens. If the alien himself had to put up the cash bond it would be reasonable evidence that he would not become a public charge. Cash bonds, as here urged, would force the steamship companies to be more careful in permitting the embarkation of aliens who would probably be excluded on arrival here, because far fewer such would be allowed to enter on appeal. Another most desirable result of such bonds would be the very great decrease in the harassing and laborious work of hearing appeal cases in the office of the secretary of labor, and would thus also largely do away with the present conditions of political pressure for the admission of aliens on appeal. Finally, cash bonds would, without any doubt whatever, result in the landing of a very greatly reduced number of undesirable aliens.

Cash bonds, of considerable amounts, were recommended by the Sub-Committee on Immigration of the Eugenics Committee of the United States of America in its first report (January, 1924).

II. Medical Inspection to be made during the Voyage

The impossibility of conducting thorough medical examinations during the hurried inspection at the port of arrival has led to a demand that such examination should be carried on during the voyage, when there would be ample time for the work, and when the aliens could be observed for several days in succession. Definite action looking towards this end was taken at a conference of alienists and social workers held in New York City, November 16, 1912, at which the most important scientific bodies in the United States then dealing with the treatment and prevention of insanity were represented.[5]

This conference unanimously endorsed the adoption of "a provision authorizing the detail of commissioned medical officers of the U. S. Public Health Service to any vessels bringing immigrants to the United States, such medical officers being required to examine immigrants, with special reference to their mental condition, on the voyage to this country." This suggestion was later embodied in a section of the Act of 1917, authorizing the secretary of labor to enter into negotiations with the transportation companies with this end in view. So far as the present writer is aware, no action on

[5] American Medico-Psychological Association, National Committee for Mental Hygiene, New York Psychiatrical Society, New York State Charities Aid Association, Committee of One Hundred on National Health, New York State Hospital Commission, Immigration Committee of the Eugenics Section of the American Breeders Association.

this matter has ever been taken by our government. The National Republican Club (New York) later passed a resolution to the following effect: "In so far as existing law may be inadequate to permit the placing of inspectors and physicians on vessels bringing aliens to this country, it should be amended." This suggestion, it should be observed, applies to placing American medical officers on the steamships, and would therefore remove the responsibility from the transportation companies, where it would seem properly to belong.

Dr. Spencer L. Dawes, medical examiner of the New York State Hospital Commission, has for some years been a very able advocate of a plan which has been widely and enthusiastically endorsed.[6] Dr. Dawes's proposal is that as a prerequisite to the granting of a visa by an American consul the emigrant shall present a medical certificate (on a blank provided by the Immigration Service) embodying family and personal history, and certifying that the emigrant is not of the excluded classes. This certificate is to be based on a thorough medical examination made by a physician employed by the transportation company which is intending to bring the alien to the United States. Fines are to be provided, as at present, in all cases in which ineligible aliens are brought here. The reasons for such a provision are the necessarily hurried, inadequate medical examinations by our own officials at the port of landing; the impossibility, owing to the attitude of certain foreign governments, of having a medical examination overseas by United States officials, and the very discouraging situation here of seeing thousands of mentally and physically unsound aliens landed, either (1) because the hurried medical examination here can not detect the disabilities or (2) because of the landing of such undesirable aliens on bonds. Dr. Dawes's plan places the responsibility directly where it belongs. If the steamship company carries out the physical examination it can not complain if it should be found, on the immigrant's arrival in the United States, that any passenger is, from a medical standpoint, ineligible under the provisions of the statute. On the other hand, if medical examinations were carried out by officers of the United States at the European ports it would be impossible to shift the responsibility to the steamship company for deportation of an ineligible immigrant by reason of physical or mental disability.

A very important part of the Dawes proposal is the inquiry into the personal and family history of the emigrant, which should be minute and thorough.

[6] By the Interstate Conference on Immigration, the New York State Federation of Women's Clubs, the National Republican Club, the U. S. Chamber of Commerce, the American Mining Congress, numerous district branches of the New York League of Women Voters, etc.

If the steamship company is held responsible for the verification of this phase of the applicant's examination, all the hardship cases would be absolutely eliminated. What happens now is that an immigrant voluntarily separates himself from his family, which may be composed of one or more children mentally deficient, and then, when the alien has made enough money to import his family a howl goes up as to the separation of these unfortunates. Unquestionably here is true hardship, but it must be borne in mind that the original separation was the voluntary act of the people who desired to enter the United States.

The plan is simple, feasible and would be highly effective. Canada, which is well in advance of us in the matter of selecting her immigrants, requires a medical examination by the steamship companies' doctors, and aliens found mentally or physically inadmissible after arrival at Canadian ports must be returned at the expense of these companies.

III. Higher Physical Standards

Close students of the eugenical aspects of immigration have for many years felt that too large a proportion of incoming aliens have been of low vitality and poor physique—distinctly undesirable members of our population yet not specifically excludable under existing statutes. The matter has more than once been brought to the attention of Congress, but without result. This whole matter was carefully considered by the Sub-Committee on Immigration of the Committee on National Affairs of the National Republican Club of New York, under the able chairmanship of Mr. William Williams, and the following resolution was unanimously adopted at a meeting of the club held February 17, 1920:

The general physical requirements for males coming here to perform manual labor should be raised moderately and made somewhat more definite than they now are. While we are not in accord with those who would make these requirements as severe as those governing admission to the Army and Navy, yet we believe that by analogy certain reasonable minimum physical standards should be adopted, either by Congress or by the U. S. Public Health Service under authority of Congress, and applied to male aliens of the class referred to. After observing for a time their operation, the experience gained would show whether it was desirable also to adopt analogous physical standards in reference to other classes. Too many immigrants of indifferent general physique have in recent years been finding their way into the United States. With such standards to serve as a guide, there would be less excuse than there now is for the steamship companies to bring here laborers who, while not suffering from any loathsome or dangerous contagious disease, are nevertheless persons of poor physique or impaired general health.

This would seem to be a reasonable and logical, as it also is a most desirable, step for us to take in this matter.

IV. Mental Tests

In this very able address in Boston, November 14, 1923, already referred to, Dr. William J. Mayo spoke as follows:

> Eugenics as applied to man is still in its infancy. During the World War, tests showed that 18 per cent. of the young men drafted were not developed beyond the mental age of eleven years. Since our form of government must always be controlled by men of average intelligence, the general average of intelligence must be raised if the standards of government are to be raised. This 18 per cent. of citizens in the Boy Scout stage of development, mentally too low to be reached by reason, easily led by an appeal to prejudice, and voting solidly, are within 3 per cent. of controlling the average election. Our great safeguard, general education, will not aid them or us. Nature has fixed their mental status. This substratum of society presents one of the greatest problems of American citizenship. It will exist long after a proper settling of the immigration question, and will tax the best minds of the future to remedy.

The grave dangers that thus threaten our future race and our institutions have led eugenicists to the conviction that only aliens who attain a certain standard of intelligence should be admitted to this country.

The Sub-Committee on Immigration of the Eugenics Committee of the United States of America, in its first report, made the following brief but inclusive recommendation:

> No alien should be admitted who has not an intellectual capacity superior to the American average. Aliens should be required to attain a passing score of, say, the median in the Alpha test, or the corresponding equivalent score in other approved tests, these tests to be given in the native tongue of the immigrant. Further, if possible, aliens whose family history indicates that they come of unsound stock should be debarred.

The American median here referred to, which is now fairly well known from the Army tests, can be readily worked out for use in new tests to be applied to aliens.

Experts have estimated that had mental tests been in operation and had the "inferior" and "very inferior" immigrants been refused admission to the United States, over 6,000,000 aliens now living in this country, most of them potential fathers and mothers of future Americans, would never have been admitted. It surely is high time for the American people to put a stop to such a degradation of American citizenship and such a wrecking of the future American race.

That mental tests as here recommended would certainly operate to debar large numbers of aliens who are of inferior intelligence is perfectly certain. On the other hand, it is no less clear that the

public as a whole is not yet educated up to an acceptance of such tests as a logical part of our immigration policy.

V. Registration of Aliens

With the increasing restrictions which have been put upon immigration, the smuggling and surreptitious entry of aliens across the Canadian and Mexican borders and by sea have naturally enormously increased. It has been estimated that probably 100 aliens daily enter this country in violation of our laws, and the number may be very much larger. While many of these "bootleg" immigrants are probably mentally and physically up to the very low standards which we have set, the majority doubtless belong to the diseased and defective classes who should most rigidly be excluded. The new Border Patrol, made possible by an appropriation of $1,200,000 for the current year, will help to remedy this very bad situation. But more is needed. Secretary of Labor James J. Davis strongly advocates a plan for registration as an effective way of outwitting the border-jumper and the smuggled alien. Under this plan every alien would be required to register or enroll annually. Failure to register would be punishable by fine. Registration would be carried out by the naturalization service of the Department of Labor and perhaps also by interested individuals and organizations. A final check-up of aliens who failed to comply with the law would occur when an alien applied for his citizenship papers. This plan would not only help in the work of assimilation and education, but, what is of even more importance, would reveal the presence of aliens who had entered the country in violation of the law, in whose cases there would be no record of legitimate admission by immigration inspectors.

Summary

In conclusion, the various methods which have here been discussed for raising the mental and physical standards of our immigrants may be briefly summarized. (1) Our immigration laws should be rigidly enforced all along the line. (2) "Mandatorily excludable" aliens should never be admitted. (3) All border-line cases, which are mostly those liable to become public charges for medical reasons, should be debarred unless there is *very strong* evidence in favor of admission. (4) Appeals from adverse decisions of the boards of special inquiry should rarely be sustained. (5) There should be no yielding to political pressure in the case of any alien who belongs to any of the excluded classes. (6) When, in very rare cases, aliens are admitted under bond, the bonds should

be cash bonds, in considerable amounts. (7) As a prerequisite to the granting of an "immigration visa" by an American consul, the alien should present a medical certificate from a physician employed by the steamship company to the effect that such alien is not of the excluded classes. If diseased or mentally or physically defective aliens are found by our examining medical officers, the steamship companies should be fined, and the alien deported. (8) Higher physical standards should be required. (9) No alien should be admitted who has not an intellectual capacity superior to the American average. (10) All aliens should be required to register annually.

THE MANAGEMENT OF FOREST PROPERTIES IN THE CALIFORNIA PINE REGION AS A PROBLEM IN APPLIED ECOLOGY[1]

By S. B. SHOW

U. S. FOREST SERVICE

THE most important and difficult task of the practicing forester in the Forest Service is that of handling the cutting of the mature forest so that a new forest may follow promptly.

I have pointed out elsewhere the profound influence that fires have exerted on the virgin forest. The various stages in the process of forest destruction may more or less arbitrarily be summarized as: (1) The relatively fully stocked forest, utilizing well the available space and food, but slightly affected by fire, showing a low percentage of fire-scarred trees; (2) the half-stocked forest, the mature trees badly scarred, distribution patchy, with underbrush and young trees struggling for the space released by death of veterans; (3) the very open and decadent remnants of the forest, with brush in the ascendency; (4) the brushfield.

One of the important influences of repeated fires, acting through the creation of fire scars, has been to make possible the attack of wounded trees by wood-destroying fungi. Thus, at all stages in the combat between forest and fire, the forest trees, varying with species, are affected by fungi.

Fire, aside from reducing the virgin forest, has a selective action in stands composed of more than a single species. The yellow and sugar pine are decidedly more resistant to fire than are Douglas and white firs and incense cedar. Thus the virgin forest of to-day, after centuries of recurring fires, displays a higher proportion of the pines than if normal and uninterrupted succession had been operative, for the firs and cedars are markedly more tolerant than the pines and thus must inevitably tend to dominate mixed stands, assuming no disturbing element such as fires.

It is thus impossible to assume that the composition of an existing mixed forest furnishes a reliable criterion of what that forest may become, once fires are stopped. How radically the composition may change is indicated by data covering 250,000 acres in Lassen County. On the basis of the composition of mature forest, 80 per

[1] Given at joint meeting of Ecological Society and Society of American Foresters, American Association for the Advancement of Science, Stanford University, June 27, 1924.

Repeated fires in the virgin pine forests of California are responsible for a marked change in the composition and character of the forest. Trees, if not killed, are fire scarred at their base and weakened so that later they become an easy prey to beetles and to wind. In the openings, where groups of trees have been killed out, a dense brush growth comes in and each succeeding fire is more intense and more destructive than the preceding. In this brush, seedlings have a hard struggle for existence.

The final results of repeated fires is the brushfield. Repeated fires kill off all seed trees and prevent the reproduction from becoming established. With repeated fires there is a deterioration of the site through the loss of humus and the finer soil particles, washed away when the soil is exposed. Even with protection for many years, nature can not reclaim the area.

cent. is classed as yellow pine type, with a small admixture of white fir. Considering the advance reproduction which will form the basis of the new stand, only 51 per cent. can be classed as yellow pine type or 64 per cent. of the area, as judged by the mature timber.

Still considering only the physical facts of the situation, it is to be noted that studies over a period of twelve years show clearly that the advance reproduction is by far the safest and most certain means of continuing the forest. Reproduction after cutting is generally difficult and uncertain to secure and where advance reproduction is present, it should be saved.

The advance reproduction, starting under the virgin forest, naturally has a higher percentage of the tolerant climax species than of the intolerant pines, the persistence and dominance of which is largely due to fire.

One further important consideration is the vastly greater amount of defect due to fungi in the tolerant firs than in the intolerant pines.

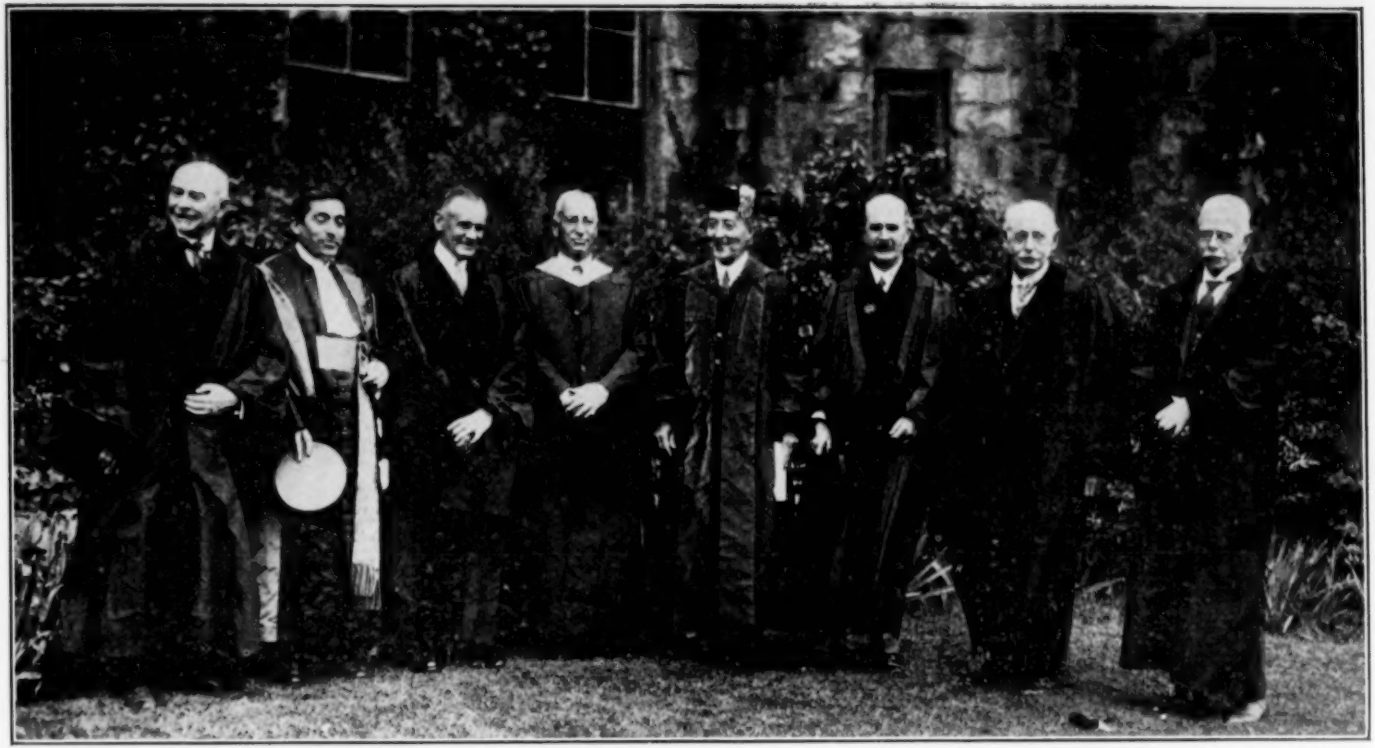
Turning to the economic factors that affect the management of national forest timber, we find that the wood of the firs and cedar is very much less prized than that of the pines. The difference is so great that only with difficulty is it possible to secure cutting of the firs to as great a degree as is desirable for the health and productiveness of the new forest. Greater defect of the firs accounts for a large part of the difference in esteem between these species and the pines, but inherent qualities of wood also tend to throw values in the same direction. Because of this, it is very desirable to maintain the pines as important constituents of the new forest, though this does not necessarily mean any attempt to eliminate the firs and cedar.

The problem in a nutshell thus is to control in some degree the progress toward domination of the tolerant and relatively nonvaluable firs, without the deliberate sacrifice of the advance reproduction in which the firs predominate.

In countries with a more intensive silvicultural management than our own, composition is controlled in mixed stands by artificial regeneration or by adjustment of time and methods of cutting to meet the seed production and conditions for establishment of the particular species it is sought to favor. With the very crude silviculture now possible in the western United States, neither planting nor flexibility in locating cutting areas can be systematically employed. The most that can be done is to create the best possible conditions for the establishment of the pines and to leave abundant seed trees.

While the firs and cedar easily outstrip the pines in establishment of reproduction under the virgin forest, it is apparently the reverse under the altered conditions resulting from heavy cutting of the virgin forest. I say apparently with deliberation, for our investigations are not at all decisive on this point. Not only is reproduction after cutting generally slow, but the amount of attention given the subject has been seriously inadequate. It is clear that a moderate cutting, removing say two thirds of the merchantable volume, does not always go far enough to distinctly favor the pines, even when every effort is made to cut the firs heavily and the pines lightly. Yet for flexibility in managing forests, it is often desirable to practice just such a type of cutting.

Thus, in order to attain the desired objective of full utilization of the land with forests containing the pines as well as the firs, it is necessary not only to recognize the basic facts—the inevitable tendency toward the climax forest of fir—but to utilize in full the act of cutting as the only tool available to arrest the progress of normal succession.



SCIENTIFIC MEN AT THE CENTENARY OF THE FRANKLIN INSTITUTE

At the celebration of the hundredth anniversary of the Franklin Institute in Philadelphia, a convocation was held at the University of Pennsylvania, and the honorary degree of doctor of science was conferred on the distinguished scientific men shown in the photograph. From left to right are: Dr. Edwin Wilbur Rice, Jr., honorary chairman of the General Electric Company; Professor Charles Fabry, of the University of Paris; Dr. William C. L. Eglin, president of the Franklin Institute; Dr. J. Hartley Merrick, vice-provost of the University of Pennsylvania; Dr. Josiah H. Penniman, provost and president of the University of Pennsylvania; Sir William Henry Bragg, the Royal Institution; Sir Charles Algernon Parsons, the British engineer, and Professor Pieter Zeeman, the University of Amsterdam.

THE PROGRESS OF SCIENCE

By Dr. EDWIN E. SLOSSON
SCIENCE SERVICE, WASHINGTON

the University of Paris; Dr. William C. L. Eglin, president of the Franklin Institute; Dr. J. Hartley Merrick, vice-provost of the University of Pennsylvania; Dr. Joslin H. Penniman, provost and president of the University of Pennsylvania; Sir William Henry Bragg, the Royal Institution; Sir Charles Algernon Parsons, the British engineer, and Professor Pieter Zeeman, the University of Amsterdam.

THE SPEED OF LIGHT

LIGHT is the swiftest thing in the world, speaking either practically or theoretically. Practically, because we do not know of anything faster. Theoretically, because we can not conceive of anything faster. For, according to Einstein, a body gains in mass as it gains in speed. To push the smallest particle faster than light would require an infinite force and infinite forces do not exist outside of books.

The velocity of light through empty space seems to be one of the inexorable limitations of nature like absolute zero. It is a constant quantity that turns up in all sorts of calculations. It is not only the speed of the visible rays of light, but also of the X-rays that are some ten thousand times shorter and of the radio rays that are more than a million million times longer. The flash of a firefly and the rays of the sun travel at this same velocity. It is the yard stick by which the starry heavens are measured, and molecular magnitudes as well. It gives us a fixed standard for time. Consequently it is important that its value should be known as exactly as possible.

But the reason given by Professor A. A. Michelson, of the University of Chicago, for undertaking a new determination of this constant was different from any of these. When asked by a member of the U. S. Coast and Geodetic Survey why he was going to put in the summer repeating the experiments, since previous observers had already got remarkably close figures, he answered, "Because it is such good fun."

Then, seeing that this reply did not satisfy the interlocutor, he added another and more practical reason, that if the velocity of light is known to one part in 200,000, it would be possible to set up a flash light on one peak and a mirror on another as far away as could be seen, and so get the distance between them in two weeks as accurately as it can now be measured by the chain in two years. This method would also be of use in determining distances where direct measurements are impossible.

Timing the speed of light has been a hobby of Professor Michelson from boyhood. When he was a midshipman at Annapolis, he set up a new form of apparatus with a range of 2,000 feet along the sea wall of the Naval Academy, and got better results than had been obtained before. Later he assisted Professor Simon Newcomb in a series of determinations.

In 1923 he took up the work again in California on a longer range and with more delicate apparatus than ever, but the forest fires made the air too hazy. But last summer he succeeded in getting excellent determinations which he has reported at the centenary celebration of the Franklin Institute.

The method used is so simple that any one can understand it, although the difficulty of carrying out a determination with such unapproached precision can hardly be appreciated. It consisted essentially in sending

THE FRANKLIN INSTITUTE

The building erected at Philadelphia in 1825 is occupied to-day by the Institute and houses one of the largest and most important technical libraries. From a print in the book issued to commemorate the centenary of the institute.

a beam of light from one mountain peak to another at known distance, reflecting it back from a mirror there, and timing the round trip. The sending station was located on Mount Wilson, not far from the hundred-inch telescope, the largest in the world. The receiving and reflecting station was on the top of Mount San Antonio, 22 miles away. The distance was measured by the U. S. Coast and Geodetic Survey with an accuracy of two parts in a million.

The source of the ray was a powerful electric arc lamp giving a light almost as bright as the sun. Passing through a minute hole in front of the lamp the ray was caught on a revolving octagonal mirror, sent to Mount San Antonio, reflected back from there and received on the original mirror which is revolved at such a rate as to catch the returned ray on the succeeding face of the octagon. The mirror was rotated by a blast of air playing on a little windmill, and made 530 revolutions a second, its speed being regulated by a tuning fork of known pitch. The making of the mirror was one of the most delicate parts of the apparatus for if the angles of the octagon were not exact, the results would be erroneous. When this was completed and its angles tested, they were found to be equal with an uncertainty of only one part in a million.

In this simplified apparatus only two measurements are necessary: (1) the distance between the two stations which is known by direct measurements, and, (2) the time of the round trip, which is given by the speed of the rotation of the mirror. The average results of eight observations gives the velocity of light in a vacuum as 186,300 miles per second. This can not be wrong by more than twenty miles.

But Professor Michelson is not yet satisfied. He will try it again next summer and hopes to get it right within a mile by steadying the speed of the mirror. He thinks it possible that the distance may be extended to a hundred miles which would enable him to get the figure accurate to within one part of a million.

Let's hope, for other reasons as well, that there will be no forest fires in California next year.

THE MELTING POT

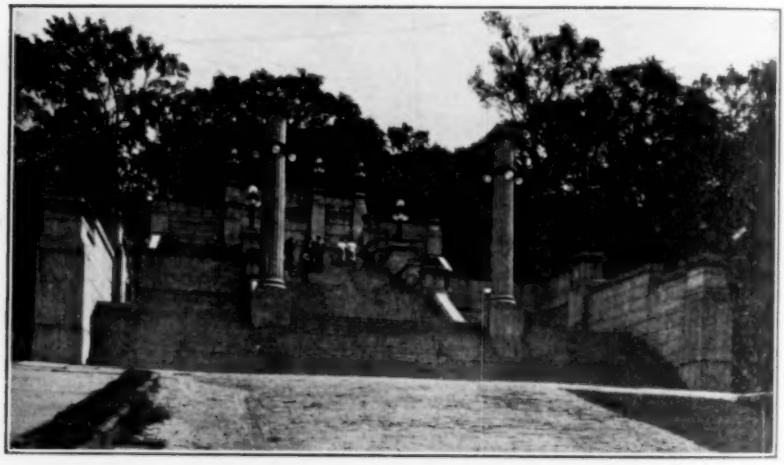
How long does it take a racial melting pot to melt? We are, as the newspapers word it, "making new Americans" at the rate of five thousand a day, if we take the highest record of the New York Naturalization Bureau; fifteen new citizens for every minute that the court was in session.

Never before in the history of the world has such a fusion furnace been run at such high speed or on so large a scale or with such diverse ingredients as our modern American amalgamation process. How long will it take for the mixture to form a homogeneous mass, without blow-holes or segregated crystals to weaken the metal?

Seven or eight hundred years. That at least is the most definite estimate I have been able to find. It comes from Flinders Petrie, Egyptologist of the University of London. In his remarkable book, "The Revolution of Civilization," he traces the rise and fall of eight successive culture periods, and finds that their average duration is between 1,300 and 1,500 years, "from shirtsleeves to shirtsleeves," to put it in American parlance, though perhaps we should say "from bare arms to bare arms."

THE PITTSBURGH BUILDING OF THE RENSSELAER POLYTECHNIC INSTITUTE

Housing the library and the administration offices



THE BROADWAY APPROACH TO THE RENSSELAER POLYTECHNIC INSTITUTE

At the top of the steps was unveiled a tablet on the occasion of the celebration of the centenary of the Rensselaer Polytechnic Institute commemorating this event and the founder of the institute, Stephen Van Rensselaer. The centenary was celebrated on October 3 and 4, with representatives in attendance from universities and engineering societies from the United States and abroad. In the issue of THE SCIENTIFIC MONTHLY for October, 1924, will be found an article on "The Rensselaer Polytechnic Institute and the Beginnings of Science in the United States," by Professor Ray Palmer Baker.

Once a people has sunk into senility, it can only be regenerated, according to Professor Petrie, by the infusion of new blood, that is, by admixture of race. For complete assimilation of the foreign element some seven or eight centuries are necessary. Then the nation is at the height of its energy and ability, and may maintain its superior civilization for four or five centuries before it begins to collapse and finally to relapse into barbarism.

Such may be the lesson of history, and it may serve to allay our American impatience and teach us to realize that it is likely to be a long time and may be a hot time before our ideal 100 per cent. American appears. But we may question whether such deductions from the past are applicable to the unprecedented conditions of the present. Two new and fundamental factors have recently entered into the problem, the deliberate restriction of both kinds of "immigration"—the foreign-born and the native-born additions to our population.

Dr. Harry H. Laughlin, of the Eugenics Record Office of the Carnegie Institution, said at the recent Toronto meeting of the British Association for the Advancement of Science that "the greatest turning point in human history was reached when mankind conceived the idea of consciously controlling his own evolution. If this principle is to be put into effect, then control of immigration is one of the major factors in human evolution, and the element most easily managed by national law and international agreement."

According to Dr. Laughlin's investigations, only 11.3 per cent. of the 13,920,692 foreign-born men in the United States in 1920 were making any addition to the native intelligence of the American people. Slightly more than 26 per cent. were of average intelligence, while 62 per cent., or close to 8,000,000 men, were below the average. He therefore concludes that "the immigrants of the last generation have not improved the average quality of the American people."

A still more pessimistic view was expressed at the Toronto session by Professor William McDougall, psychologist of Oxford and Harvard. "As I watch the American people speeding daily, with invincible optimism, down the path that leads to destruction, I seem to be watching one of the greatest tragedies of history," he said, and again, "I fear that when a few hundred years hence, the list is made up of the great nations whose decline is due to the deterioration of the race which composed them, England will have to be added to such nations of the past as Greece, Rome, Persia, Egypt and Spain."

Professor McDougall thought three measures would be necessary if the racial stock is to be kept from decline. First, knowledge of birth control should be disseminated by clinics to all classes. Second, immigration should be selective, which the United States is beginning to try. Third, men of proved ability, such as engineers, skilled workmen and college professors, should be paid in proportion to the number of their children. This plan was adopted for privates in the British army during the war and has been applied to the fellows of the National Research Council of the United States, and is being considered in France.

There is some disagreement among geneticists as to the extent of the damage being done to our racial stock by present dysgenic tendencies and more disagreement as to the eugenic measures best to counteract them, but all agree that quality and not quantity is now the important problem in

BUST OF PASTEUR

Recently unveiled at the American Institute of Baking in Chicago by Professor S. P. L. Sorensen, director of the Carlsberg Laboratories in Copenhagen, left, and Dr. Max Henius, president of the Wahl-Henius Institute.

population. G. Udny Yule, of Cambridge, using the mathematical formula of Verhulst, of Belgium, arrives at almost the same figure for the natural limit of the population of the United States that Professor Raymond Pearl, of Johns Hopkins, reached independently, namely, about 199,000,000. According to this our country is already more than half filled up and the danger is lest it should fill up too fast and with the wrong sort of folks. No nation ever started out in life with a larger and better assortment of chromosomes, but we should see to it somehow that the best of them do not get lost in the shuffle.

THE SENILITY OF CIVILIZATION

Day by day the newspapers report the excavation of the buried city of Magna Leptis in Tripoli, as last year they told us of the excavation of the buried tomb of Tut-Ankh-Amen in Egypt. We receive from these researches the same shock of surprise at the realization there were people so long ago who accumulated wealth and spent it in the pursuit of pleasure even as we do, who cultivated art and learning, and believed, like us, that they had reached the pinnacle of human attainment, and yet that their proud achievements had been so drifted over by the sand of time that their very existence had been forgotten. The resurrection of such entombed civilizations serves for us the same purpose as the ancient Egyptian custom of passing around an image of a mummy at a feast, a memento mori, a reminder that civilizations like men are mortal, and that, if we may judge the future by the past, our own will perish too and be forgotten.

Helmolt in his history of the world observes that "It is remarkable that even to the present day every philosopher, who has compared the processes of man's development to the several periods in the life of the individual, has believed his own time to be the age of senility." It has seemed to each successive generation, as it did to Bernard of Cluny in the twelfth century, that "The world is very evil, the times are waxing late." In every previous century, as in ours, there have been those who have expected the world to come to an end within the lifetime of men then living. Humanity has persistently maintained a *fin de siècle* attitude, regardless of the calendar.

> There is the moral of all human tales,
> 'Tis but the same rehearsal of the past.
> First freedom and then glory—when that fails,
> Wealth, vice, corruption, barbarism at last,
> And history with all her volumes vast
> Hath but one page.

But while all the physicians, who feel themselves called to consider the health of humanity, agree that the patient is in a very dangerous state and likely to pass away at any time, they fail to agree on the diagnosis of the disease leading to the fatal termination. According to some, it is too much selfishness; according to others, it is excessive altruism. Some call the malignant microbe democracy; others call it plutocracy. Some see the danger in nationalism; others in internationalism. The leading prophet of the latter school is Oswald Spengler, who has recently brought into action a 42-centimeter gun in the form of two profound volumes on "The Downfall of Western Europe." His position is shown by the following quotation: "A nation is humanity in living form. The practical result of theories of world-betterment is, without exception, a formless and there-

fore unhistorical mass. All cosmopolitans and enthusiasts for world-betterment represent fellaheen-ideals, whether they know it or not. Their success means the abdication of the nation within the historical sphere, to the advantage, not of world-peace, but of other nations."

Professor J. W. Gregory, of the Glasgow University, thinks, like Lothrop Stoddard, that the progress of European civilization has been checked by the rising tide of color. At the recent Toronto meeting of the British Association for the Advancement of Science, he said: "During the past half-century the unprecedented increase in the white race has been exceeded by that of the colored people. Increased disparity in numbers means, in a democratic age, an inevitable transfer of power; while the former prestige of the white man has been undermined by his own beneficent rule. Alike in war and peace the personal authority which the white man held in 1900 has undergone a momentous decline. White colonists have no chance of permanently occupying land near the overcrowded parts of Asia or accessible to the fast multiplying Negroes of Africa. White merchants may find in these regions profitable trading centers and may for a time rule and administer them; but when white enterprise has subdued the land, built railways and utilized the rivers, the colored man will oust the white from all but the few posts that require experts."

A. J. Hubbard in "The Fate of Empires" considers it a problem of reconciling the interests of the transitory individual with those of the continuing race. He puts his point in a neat analogy: "Life is an entailed estate. It is to the interest of the life tenant to break the entail." The conflict can not be reconciled by reason, so he concludes that "A true and stable civilization can never be more than a by-product of religion."

Certain psychologists are now working up a series of intelligence tests to measure the gradual onset of senility as the school tests measure the development of maturity of mind. It is time that the social psychologists worked out a system of diagnosis applicable to nations so that the development of fatal maladies could be discovered at incipiency, and, if possible, averted.